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American Institute of Electrical Engineers

COMING MEETINGS

Pacific Coast Convention, Pasadena, Cal., October 13-17

MEETINGS OF OTHER SOCIETIES

American Institute of Chemical Engineers, Denver, Col., July 16-19

American Mining Congress, Sacramento, Cal., Sept. 29-Oct. 4

American Elec. Rwy. Assn., Atlantic City, N. J., Oct. 6-10

Inst. of Metals Div., American Institute Mining & Metallurgical Engrs., Milwaukee, Wis., Oct. 11-18

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American Institute of Electrical Engineers

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Current Electrical Articles Published by Other Societies

Transactions Illuminating Engineering Society, May, 1924

Unit Costs of Industrial Lighting, by D. H. Tuck, pp. 411-23

Present Practise in Motor Bus Lighting and Suggestions for Improvement, by C. L. Porter and A. C. Roy, pp. 456-74

New York Electrical Society, March, 1924

High Voltage Phenomena, by F. Faccioli

Western Society of Engineers, May, 1924

Underground Cable Practise in Europe, by D. W. Roper, pp. 217-24

Proceedings U. S. Naval Institute, June, 1924

Some Phases of Radio Telephone Broadcasting, by A. H. Tawresey, pp. 893-902.

Journal of the A. I. E. E.

Devoted to the advancement of the theory and practise of electrical engineering and the allied arts and sciences

Vol. XLIII JULY, 1924 Number 7

New Type of Convention Proves a Success

A convention which made Institute history was held in Worcester, Mass., early in June. This was the first convention held by a geographical district of the Institute. Much credit must be given to the officers and sections of the district, District No. 1, for their courage in undertaking such a meeting with no precedent for guidance, and they are to be complimented also on the excellent way in which the meeting was planned and conducted. A report of the meeting is given on another page of this issue.

It is certain that other districts are much interested in the success of this convention. It showed the possibility and desirability of holding similar meetings in other parts of the country. It proved, furthermore, that such a type of convention has advantages which are not offered by either Section meetings or national Institute meetings.

Chief among these advantages is the fact that high-calibre papers can be presented and discussed at considerable length. It is not necessary to condense so stringently as in a national meeting. Then, on account of the larger and more diversified audience, the discussion should be more thorough than in a Section meeting. A further advantage is that those attending are mostly from neighboring sections and consequently their interests are fairly closely related. Also, as this is a convention of neighbors, many of whom know each other, there is a very desirable atmosphere of informality.

These advantages, together with the opportunity which such a meeting offers for building up interest in the Institute, will appeal to many Districts and it is safe to predict that other District conventions are going to be held in the future.

Engineers Sail for Europe

The World Power Conference, London, June 30 to July 12, previously referred to in the JOURNAL, has attracted a large number of American engineers, and a group of about two hundred persons, of which about half were ladies, sailed on the Cunard Steamer *Scythia* from New York, June 19. Many others have sailed on other steamers.

About sixty members of the A. I. E. E. will attend, thirty-five of whom, with members of their families, sailed on the *Scythia*.

In addition to the World Power Conference, there are to be numerous other meetings of engineering interest in London, and also on the continent, this summer. As previously announced in the JOURNAL, the A. I. E. E. was invited by the Institution of Electrical Engineers of Great Britain, to designate a delegation of members and the ladies of their families to participate in various meetings and other events under the auspices of the I. E. E. in London, July 10-15, immediately following the World Power Conference. This invitation was accepted by the Board of Directors on behalf of the membership; and accordingly, the delegation referred to above has been appointed by the President of the Institute. An Executive Committee of five members of the delegation has been named to act upon the various matters that will require attention. This committee is as follows: Past President John W. Lieb, Chairman, F. L. Hutchinson, Secretary, P. Junkersfeld, C. E. Skinner, and Calvert Townley. The members of this committee were included in the group which sailed on the *Scythia*.

On Wednesday, June 18, the members of the engineers' party were entertained at luncheon on board the *Scythia* as guests of the Cunard Steamship Company, Fred R. Low, Editor of "Power" and President of A. S. M. E., presided. Among the other speakers were Henry J. Pierce, General Vice-Chairman of the American Committee of the World Power Conference; Commander N. T. McLean of the U. S. S. Colorado; John W. Lieb, David B. Rushmore, and Calvert Townley.

Third Pan American Scientific Congress

The Third Pan American Scientific Congress, in accordance with the decision of the Second Congress held in 1915 at Washington, D. C., will be held at Lima, Peru. The decree of the Peruvian government, under whose auspices the Congress will be held, has named December 20, 1924 as the inauguration day and the sessions will continue during the fortnight following.

The program of the Congress calls for the presentation of papers in all branches of science, both general and abstract, as well as papers bearing particularly on questions concerning the Continents of America. Immediately after the closing of the Congress the official festivals to commemorate the first centenary of the Battle of Ayacucho will be held.

The Congress will comprise nine Sections, the

Presidents of each of which have been appointed. The Sections are as follows: Anthropology, History and related Sciences; Physics, Mathematics and related Sciences; Mining, Metallurgy, Economic Geology and Applied Chemistry; Engineering; Medicine and Sanitation; Biology, Agriculture and related Sciences; Private, Public and International Law; Economics and Sociology; Education.

The Organization Committee of the Congress is anxious that it shall live up to the success of the foregoing ones and asks the warm support of all American Scientific Institutions.

The appointment of one or more delegates from the Institute is asked, together with collaboration in the presentation of papers. It is requested therefore that any members of the A. I. E. E. who expect to attend or be in South America at the time of the Congress advise the Secretary's office, 33 West 39th St., New York, at once.

Some Leaders of the A. I. E. E.

Elihu Thomson, the fifth president of the Institute, was born in Manchester, England, March 29, 1853. He came to the United States with his parents in the year 1858. The family located in Philadelphia.

He graduated from the Central High School, Philadelphia, in 1870, and was at once appointed assistant professor of chemistry of that institution. In 1876 he was advanced to full professorship, remaining in that position until 1880 when he resigned to devote his entire time to electrical research.

Professor Thomson's first important invention was the three-coil arc dynamo which, with its automatic regulator and other novel features, formed the basis of the successful electric lighting system produced by the Thomson-Houston Electric Company, beginning in the year 1880.

The Thomson-Houston Electric Company, established in Philadelphia in 1879, was moved in the year 1880 to New Britain, Connecticut, where it remained three years, then moving to Lynn, Massachusetts. In 1892 the company merged with the Edison General Electric Company, becoming the General Electric Company. In the early years of the new company Professor Thomson was electrician and chief engineer, many of the fundamental inventions upon which the present industry is based being his.

As consulting engineer of the General Electric Company, Professor Thomson is still actively engaged with the problems of the industry. His inventions touch all angles of electric application and his United States patents alone exceed six hundred in number.

Professor Thomson received honorary degrees of A. M. from Yale, 1890; Ph. D. from Tufts, 1894, and Sc. D. from Harvard, 1909. He received from the French government the decorations of Chevalier and Officer of the Legion of Honor; was awarded the Rumford Medal, 1901; the Grand Prix at the Paris Expositions of 1889 and 1900; was the first recipient of the Edison Medal, 1910. Later he received the Elliott Cresson Gold Medal from the Franklin Institute, having previously received twice the John Scott Legacy Medal for electrical inventions. In 1916 he received the John Fritz Medal, founded by the four National engineering societies.

Professor Thomson is a member of the Corporation of the Massachusetts Institute of Technology, past president of the International Electrochemical Commission, 1908-1911, and is an officer or member of many other international and national technical organizations formed in the interest of the advancement of science.

A Single-Unit 110,000-Volt Insulator Proposed

Anything that is new is rightly received with conservatism by engineers, particularly as regards its immediate and complete adoption in lieu of the older—and perhaps less efficient—equipment or methods which have already established themselves after trial in the fire of practical service experience. But all new developments deserve and receive hearty and cordial encouragement as possible better or cheaper tools to advance the electrical art.

What many engineers regard as an epoch-making contribution to the art of transmission was announced at the A. I. E. E. convention in Worcester last week by Prof. H. B. Smith. As a result of a long period of development, he described and exhibited a new type of insulator proposed for high-tension systems, provided that field-service tests give results corresponding to laboratory tests. In other words, a beautiful piece of engineering research came to fruition with a finished product embracing tremendous potentialities whose realization must await the results of an apprenticeship under service conditions.

The striking character of the insulator lies in its use of metal and wood, its design for operating at 110,000 volts per unit, its close ratio of wet and dry breakdown values and its conformation to utilize field effects to a maximum degree. From a technical standpoint it is fundamentally sound; its questionable features are those associated with service conditions. The tendency for wood to carbonize has prohibited its use in the past, for any initial carbonization originating from leakage or static tends to continue and spread. Professor Smith claims that the perfection of impregnation processes and the rational design used will prevent any carbonization in the proposed insulator. In addition, the insulator possesses possibilities in maintenance that may economically permit of stick replacements at intervals. But all the industry will, in any event, pay honor to the college professor and his associates, who have made a very promising contribution to the art. —*Electrical World*.

A New Type of Single-phase Motor

BY S. R. BERGMAN
Associate, A. I. E. E.
Consulting Engineer, General Electric Company,

Review of the Subject.—*This paper deals with the development of a constant speed a-c. motor for application to single-phase current. A description is given of the derivation of this new type of motor from the plain repulsion motor. The novel feature lies in the armature which consists of a combination of three elements, namely: a commutated winding, a squirrel cage of high reactance, and a commutating device consisting of shielding metal strips.*

It is shown that this motor in starting and acceleration possesses the characteristics of a series motor and when up to speed has the characteristics of a shunt motor. The changing over from the series to the shunt type is accomplished without the use of any automatic device, this change taking place due to the inherent qualities of the motor.

An explanation is given of the high power-factor possessed by this motor and also an elementary theory of commutation, which has proved to be as good as that in a d-c. motor with commutating poles.

WHEN looking back on the development of the electric motor, it appears that the traction motor with its severe service has had a great influence on both the mechanical and electrical design of the stationary motor for general purposes. Both for d-c. and a-c. applications, the traction motor has served as a model and particularly has its influence been strongly felt in the evolution of the a-c. motor. Great contributions to the art of the a-c. motor are found in the records of the A. I. E. E., which records describe not only discoveries of new means of improving results, but also establishing the theories governing the operation. Chief among these contributions are the papers by Lamme on the Series Motor; Steinmetz, on the Repulsion Motor; Alexanderson, on the Series Repulsion Motor; and Milch on the Repulsion Induction Motor. All of the motors mentioned, except the Milch motor, have the characteristics of the series type, the Milch motor approaching shunt-motor characteristics.

The new motor which will be described in this paper has the characteristics of a shunt motor over the running range, and the series type characteristics during starting and acceleration. The change over from the characteristics of the series motor to that of the shunt motor is accomplished in this new motor without the use of any external automatic device. Since the motor is a combination of a repulsion motor and a squirrel cage induction motor, for want of a better name, it will be referred to as the squirrel cage repulsion motor.

Through the work of Steinmetz and Alexanderson above referred to, the characteristics of the plain repulsion motor are well understood. In Fig. 1 is shown diagrammatically, Professor Elihu Thomson's well-known repulsion motor. This motor has in many respects the same characteristics as that of a series type d-c. motor. It differs, however, from the operation of such a motor in some respects and in examination of such differences, one in particular is rather striking; namely, the difference in the speed and torque curve. The series type d-c. motor will attain very high speeds if the load is removed; whereas, the repulsion motor will not run away, but will stop at a certain limited speed. The reason for this limitation in speed is due to the influence of the currents in the coils short-circuited by the brushes, and it may be stated that the larger these currents are, that is, the poorer the commutation, the lower will be the running free speed.

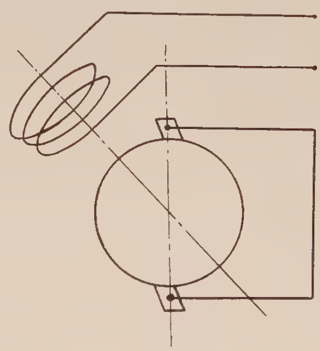

FIG. 1

With this observation in mind, the writer conceived the idea that if it were psosible by artificial means to exaggerate the influence of these short-circuited currents then it should be possible to so limit the running free speed that the result would lead to a nearly constant speed motor. In order to carry out this thought, a motor was made a number of years ago in accordance with Fig. 2. The field carries a single winding corresponding to the field winding in Fig. 1. The armature carries a commutated winding with its short-circuited

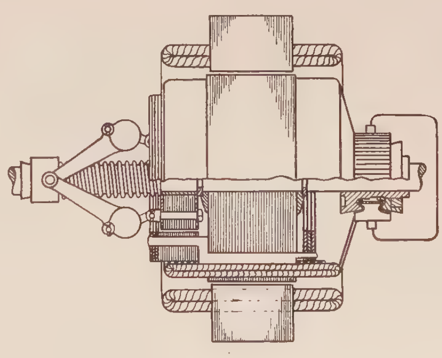

FIG. 2

Presented at the Annual Convention of the A. I. E. E., Edgewater Beach, Chicago, Ill., June 23-27, 1924.

brushes in accordance with Fig. 1, but in addition, there are placed in the same slot as the commutated winding, the bars of a squirrel cage. These bars are extended, as shown in Fig. 2, at one end projecting through a laminated ring rigidly attached to the shaft. Inside this laminated ring moves a circular core which is acted upon by a centrifugal mechanism in such a fashion that when the motor is at standstill, the moving core is entirely inside of the laminated ring, and when the motor speeds up, the inside core is moved out, until, near synchronism, the core is entirely moved outside the laminated ring. This mechanism, therefore, provides the squirrel cage with an automatically adjustable reactance which is a maximum at standstill and a minimum when running near synchronism.

When the motor is at standstill, the squirrel cage carries a comparatively small current due to the high value of the adjustable reactance, and the current is, therefore, flowing mainly in the commutated winding. Therefore, at standstill, this motor possesses about the same torque and starting current as in the case of the plain repulsion motor, Fig. 1. It is well understood that at synchronism the plain repulsion motor sets up a circular revolving field similar to that existing in the polyphase motor. Hence, at synchronism, the squirrel cage revolves at the same speed as this revolving field and is, therefore, at this speed, not producing any torque. Above synchronism, currents are generated in the squirrel cage, the condition being very similar to that of an induction generator. The torque in the squirrel cage is then a generator torque, thus opposing the motor torque in the commutated winding. Tests show that this motor will only exceed synchronism by 1 to 2 per cent. As soon as the speed drops below synchronism, the squirrel cage becomes active, producing a motor torque, and at these speeds, both the squirrel cage and the commutated winding pull together. Tests show that the maximum output, which occurred at about 10 per cent slip, was 250 per cent of the normal output; that is, very similar to a well designed polyphase induction motor. The power-factor was very excellent; *i. e.* close to unity, which is far better than that of either a plain repulsion motor or a squirrel cage induction motor, for reasons which will be explained in the following. The commutation of this motor was excellent, as good as that of a well designed d-c. motor with commutating poles. A brief theory of the commutation will be discussed later.

Although this motor performed in accordance with expectations, it was felt that it was capable of further development toward the ends of eliminating the moving parts. The thought naturally presented itself as to whether or not it would be possible to make the adjustable reactance an integral part of the motor proper.

The next step in the development was an armature structure shown in Fig. 3. The squirrel cage S is placed underneath the commutated winding R and the slots carrying these two windings are inter-connected through the narrow slot L.

No external cores are used, the result being that the squirrel cage is given a permanent high reactance. Since this is the type of motor which was ultimately adopted for production, no further account will be taken of the motor, shown in Fig. 2, which has merely been mentioned as being one link in this development.

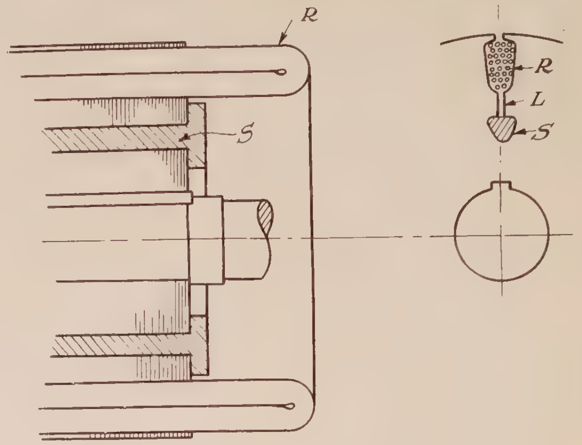

Fig. 3

In order to explain the working of the squirrel cage repulsion motor, shown in Fig. 3, the conditions existing in the plain repulsion motor will first be briefly considered. Following Steinmetz' paper of 1904, the field winding is resolved in two parts at right angle in space shown in Fig. 4. That portion of the field winding which magnetizes in direct opposition to the armature is called the compensating or transformer winding T. That portion of the field winding which magnetizes

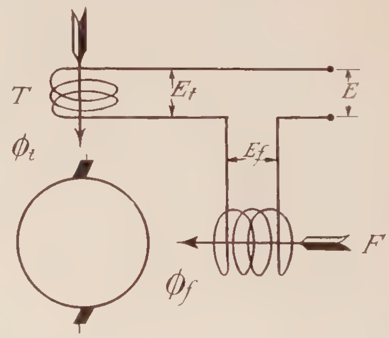

Fig. 4

at right angle to the armature is called the main field winding F. The transformer and the armature windings constitute a transformer, inter-linked by the mutual flux ϕ_t. The field winding F has no corresponding secondary winding on the armature except the coils, which are short circuited through the brushes. Since the influence of these short-circuited currents is small, below synchronism at least, these currents will be

neglected and then the field flux ϕ_f acts as pure self-induction.

When running at speed, there are two e. m. fs. induced in the armature, one E_{at} by alternation of the transformer flux ϕ_t and a second E_{af} set up due to the rotation of the conductors through the field flux ϕ_f. Since in a reactive coil the flux and the current are in phase and since the e. m. f. of rotation must be in phase with the field flux, the vectors I, ϕ_f and E_{af} are in time phase as shown in Fig. 5. Since the armature is short-circuited (neglecting the impedance drop) the e. m. f. of alternation must be equal and opposite to the e. m. f. due to the speed as shown in Fig. 5. Since the mutual transformer flux is 90 deg. ahead in time of the secondary e. m. f., the vector of the flux ϕ_t is placed accordingly in the diagram from which it now may be seen that the fluxes ϕ_f and ϕ_t are in quadrature in time.

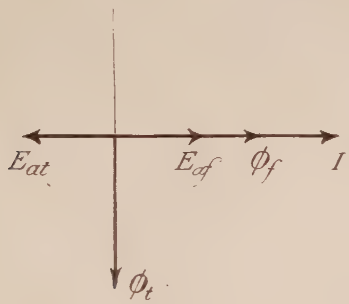

FIG. 5

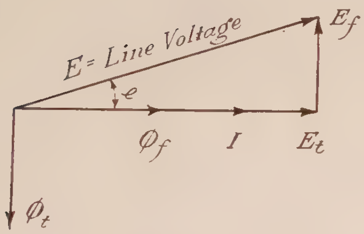

FIG. 6

Numerically, $E_{at} = C \times f \times \phi_t$, $E_{af} = C \times f_0 \times \phi_f$ where C = constant, f = primary frequency, f_0 = frequency of rotation. Hence, $C \times f \times \phi_t = C \times f_0 \times \phi_f$. At synchronism $f = f_0$. Hence, $\phi_t = \phi_f$, thus confirming the statement already made that at synchronism a circular revolving field exists.

A repulsion motor may, therefore, be looked upon as formed of two elements; namely a transformer loaded on non-inductive load in series with a reactive coil. Since, in a transformer loaded on a non-inductive load, the impressed voltage and the primary current are nearly in phase, in Fig. 6, is shown as a first approximation, the line current I in phase with the voltage E_t which is impressed on the transformer winding. If E_f is the voltage impressed on the field winding, this voltage leads the current by 90 deg. Cos φ is then the power-factor and thus Fig. 6 represents in an elementary way, the diagram of the plain repulsion motor.

It is obvious that by making E_f small as compared with E_t the power-factor will be good, which means running a weak field as compared with the armature reaction. In a repulsion motor of the size here considered, the power-factor at full load would range between 80 and 85 per cent. Test on the squirrel cage repulsion motor reveals, however, the fact that the power-factor at full load is close to unity. Thus, by adding a highly reactive squirrel cage, the power-factor has been considerably raised, a fact which at first appears paradoxical. The explanation is as follows:

In Fig. 6 we assumed that the current I in the field was in phase with the field flux ϕ_f. This is, however, not quite true even in the plain repulsion motor, since, due to the losses in the iron, there always exists an angle of hysteretic advance, and in addition, the coils short-circuited by the brushes act like the secondary of a transformer loaded on mixed reactance and resistance. In such a transformer, the primary current leads the mutual flux by a certain angle. In Fig. 7, the current I leads the field flux ϕ_f by a certain angle α. Completing the diagram, it is easily seen that the power-factor has improved since the whole voltage triangle has been turned in the diagram so as to decrease the

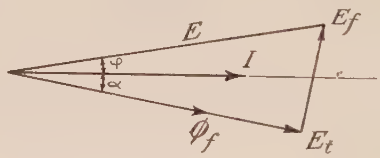

FIG. 7

angle φ. In the plain repulsion motor, the angle α is comparatively small, but nevertheless, there exists in such a motor, below synchronism, a certain amount of power-factor compensation.

It is now obvious that if a separate squirrel cage is used, a similar effect to that due to the currents short-circuited by the brushes is taking place, although, in a much more pronounced way. At full load, the squirrel cage actually delivers about the same amount of energy as the commutated winding. The primary corresponding to the squirrel cage consists of two phases; namely, the transformer winding and the field winding, each contributing about one-half of the output. Thus, at full load, each of these phases delivers about one-quarter of the output and hence, the angle α has become considerable at full load and the improvement of the power-factor is, therefore, appreciable. In Fig. 8 is shown a break test of a motor rated 3 h. p. and it may be seen that the power-factor at full load is close to unity.

It has thus been proven that by adding a highly reactive squirrel cage to the commutated winding in a repulsion motor, the power-factor, below synchronism, is improved,—a result which may at first appear contradictory, and the explanation as shown above

may best be summarized by the following quotations from Steinmetz:

"Exciting the field by a lagging current in the field, a lagging e. m. f. of rotation is produced which is equivalent to a leading current. As it is easy to produce a lagging current by self-induction, the commutator thus affords an easy means of producing the equivalent of a leading current. Therefore, the a-c. commutator is one

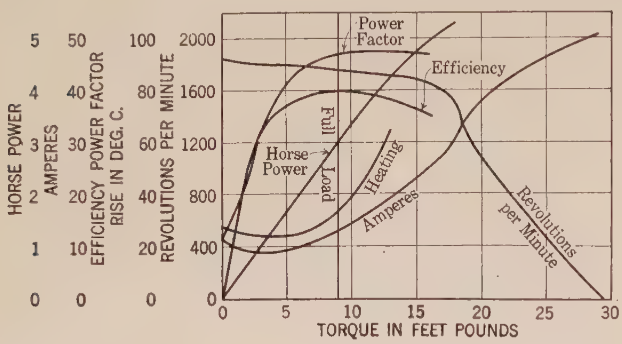

Fig. 8

of the important methods of compensating for lagging currents."

Similar conditions exist in the plain series motor in which power-factor compensation can be obtained by turning the time phase of the field flux by shunting a resistance across the exciting winding, which proposition, I believe, was first suggested by McAllister. In this case the efficiency suffers slightly due to the loss

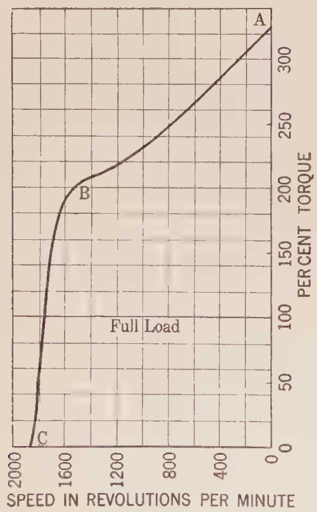

Fig. 9

in the resistance, and in addition, such an arrangement introduces a certain mechanical complication. In the squirrel cage repulsion motor, the addition of the squirrel cage cuts down the losses in the secondary, thus improving the efficiency. Thus, the squirrel cage raises both the efficiency and the power-factor, which conditions may be confirmed from the break test shown in Fig. 8.

Fig. 9 gives the typical relation between the speed and the torque for this type of motor. From this figure it may be seen that the torque curve may be divided into two branches; namely, the branch $A\ B$ corresponding to starting and acceleration and the branch $B\ C$ corresponding to the normal running conditions of the motor. During the period $A\ B$ the motor has, obviously, the characteristics of a series motor. During the period $B\ C$ it possesses in a marked degree the characteristics of a constant-speed shunt motor.

As the speed decreases and the motor performs along the curve $B\ A$, the current increases, due to the fact that the field is excited by the line current. The field flux increases with the decreasing speed. At standstill, corresponding to point A, we have the following conditions:

The squirrel cage has inherently, due to its construction, a high inductance. It is then penetrated by a current having primary frequency. Its reactance, therefore, is quite high. The commutated winding on

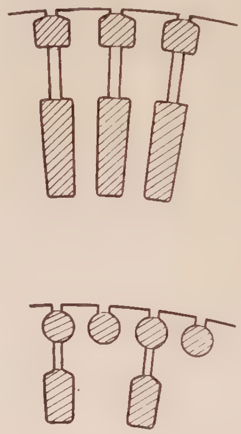

Fig. 10

the other hand has inherently a low reactance and the current, therefore, will flow mainly in this winding. We may also look upon this from a somewhat different viewpoint by stating that the magnetic flux seeks the path located between the squirrel cage and the commutated winding and thus the flux, which acts as self-induction for the squirrel cage winding, is torque-producing with respect to the commutated winding.

From the shape of the curve $A\ B\ C$, it will be seen that the torque during deceleration increases without a break from B to A, thus securing a high "pull-up" torque, guaranteeing that the motor will pull up to speed the load that it starts. Over the branch $C\ B$, it possesses, as stated, the characteristics of a shunt motor to a marked degree, the full-load speed regulation being from 3 to 4 per cent. The branch $C\ B$, therefore, corresponds to running conditions generally obtained in a polyphase motor with low secondary resistance.

Since the mechanical construction possesses a certain similarity to the Boucherot double squirrel cage induction motor, it becomes of interest to examine whether

such a similarity exists from an operating standpoint. The double squirrel cage induction motor, may be constructed in a number of various ways as shown in Fig. 10. The main principle consists in providing one squirrel cage of high resistance and low reactance and a second squirrel cage of comparatively high reactance and low resistance. This principle aims at improving the starting conditions of the squirrel cage induction motor. In starting, when the frequency in the secondary corresponds to the primary frequency, a large portion of the current flows through the high-resistance winding, thus securing a high torque efficiency. When running at speed, the frequency in the secondary is the slip frequency; that is, only a small fraction of the primary frequency, and then the secondary current seeks the path of lowest resistance, consequently, taking the path of the low-resistance winding. Thus, near synchronsim, this motor has a good speed regulation and a high efficiency. The power-factor of this motor suffers, however, for the following reason. In its reaction upon the primary, the secondary currents are of primary frequency, since they are always located in space in such a manner as to oppose the primary currents and thus the primary and secondary may be considered connected in series. It is, therefore, from the standpoint of power-factor, equally as bad to introduce reactance in the secondary as in the primary. Hence, the power factor, as well as the maximum output, suffers in the Boucherot type of motor. From this point of view, the squirrel cage repulsion motor, as has already been discussed, has opposite characteristics to the Boucherot motor, since both the power-factor and the maximum output improve by the use of the two windings.

Another distinction is the fact that the excitation in the squirrel cage repulsion motor has, in many respects, the character of that of a series motor, *i. e.*, the field flux increases somewhat with the line current. In the Boucherot motor, conditions are exactly opposite since it has the characteristics of a plain induction motor, the exciting flux (the mutual flux) decreasing with the increasing load. The two types of motors are, therefore, from an electrical standpoint, widely different.

One of the great difficulties with a-c. commutator motors has always been the question of commutation. Different means have been adopted for improving the commutation, such as the use of high-resistance commutator leads in the plain series motor in accordance with Lamme, or the use of fractional-pitch winding in the repulsion motor as suggested by Alexanderson, as well as providing for the proper commutating field also suggested by Alexanderson in his series repulsion motor. In the motor we are considering, another means for obtaining good commutation has been adopted.

In the plain repulsion motor, when it is running near synchronism, the field revolves with about the same speed as the armature conductors and, therefore, it is reasonable to assume that at such speeds the commutation is fair. The transformer flux, which is set up by the mutual action of the transformer winding and the armature, may be considered a commutating flux since it has not only the right time phase, but also the right strength to compensate for the electromotive force induced in the short-circuited coil by the field flux. On the other hand, there is another electromotive force induced in the short-circuited coils which causes sparking,—namely, the electromotive force of self-induction. In the squirrel cage induction motor, the squirrel cage is inter-linked with the leakage flux which causes self-induction in the short-circuited coils as shown in Fig. 11. The leakage flux, therefore, serves as a mutual flux of transformation between the short-circuited coil and the squirrel cage, thus transferring the energy, which would otherwise appear as a spark, to the squirrel cage. Part of this leakage flux over the length L is, however, not inter-linked with the squirrel cage and this leakage flux would, therefore, cause a slight amount of sparking. In order to eliminate this condition, a thin sheet of metal M is introduced in this slot. This metal strip is of comparatively high resistance. It should now be observed that the leakage flux over the length L must penetrate this metal strip and the corresponding energy is, therefore, dissipated in heat. In other words, instead of appearing as a spark, this energy appears as heat in the metal strips. Due to the fact that the frequency of commutation is very high, it is obvious that the resistance of the metal strips can be made quite high so as not to interfere with the flux distribution in starting, which conditions have already been discussed.

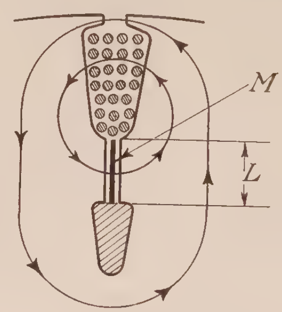

Fig. 11

Thus, the armature of this motor consists in reality of three elements, each of which has an important function. These elements are the commutated winding R, the squirrel cage S and the commutating strips M. The commutated winding secures for this motor a high starting torque and it also contributes to the output when running at speed. Due to the fact that it is connected to a commutator, it secures power-factor compensation. The squirrel cage winding procures the characteristic of a constant speed type of motor over the running range and also secures perfect commutation in combination with the commutating strips.

The Application of the Saturated-Core Reactor and Regulator

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Review of the Subject.—*The purpose of this paper is to state briefly the use of voltage regulators and reactors in transmission and distribution systems and to mention operating requirements which might be best met by the use of saturated-core type regulators or reactors. The saturated-core type regulator and reactor consists of an iron core with two sets of coils. One set of coils is connected to a d-c. circuit and the other set to an a-c. circuit. The theory, design and construction of the saturated-core type regulator and reactor is discussed in A. Boyajian's paper.*

* * * * *

VOLTAGE REGULATOR

THE economic operation of large transmission and distribution systems and the rendering of satisfactory electric service from these systems require voltage regulation and control in various parts of the system, owing to the change in voltage with load variations. Generator voltage regulators are generally employed to maintain constant voltage at either the generator or substation bus. Synchronous condensers are also used extensively to maintain a constant voltage at a substation bus by supplying wattless kv-a. to the system, thereby changing the power factor of the energy transmitted over the transmission lines. Induction type regulators are generally used in distribution feeder-circuits to maintain a constant voltage at the feeder load center. To a less extent they are used in industrial plants for regulating lighting circuits, electric furnace loads, welding loads, and electrolytic processes.

The tying together of two large stations or systems and the formation of networks or meshes by the interconnection of substations, generating stations or systems requires the use of voltage regulating equipment to control the voltage, the flow of reactive kv-a., and the energy component. Synchronous condensers are used to meet many of these conditions but there are some conditions where they will not accomplish all that is required. Synchronous condensers are generally used to hold constant voltage at certain points of the system by supplying reactive kv-a. to the system. The condensers have no control over the division of the reactive kv-a. flowing in two or more parallel paths between two points as this is determined by the impedance of the paths. Induction regulators and transformer tap-changing equipments are also used to hold constant voltage at certain points of the system, and where required, to determine the value and path of flow of either reactive kv-a., energy component, or both. Where it is required that the voltage adjustment shall follow a smooth curve, the tap-changing equipment alone is not applicable, as this equipment changes the voltage in steps as great as 2½ per cent and 5 per cent. The induction regulator, the combination of tap-changing equipment and induction regulator, and the synchronous booster give a smooth voltage adjustment. The induction regulator and the synchronous booster, however, cannot be built for very high voltages and it is necessary, therefore, on a high-tension line to use shunt and series transformers between the regulator or booster and the high-tension line or bus.

The construction of the saturated core type regulator is similar to a transformer, consisting of an iron core and coils. The saturated core type regulator, therefore, can be built for as high a voltage as can the transformer. For a 220,000-volt circuit a 220,000-volt saturated-core regulator could be built. From the voltage standpoint then, in order to justify the choice of the saturated core type regulator, it must have a lower annual charge than either the induction regulator or synchronous booster with their accompanying transformer equipment. No large, high-voltage, saturated core regulators have been built so far, and therefore, the operation and exact costs are uncertain; but from a general study of the situation the indications are that the saturated core regulator would probably be cheaper for high voltage than the well-known combination of induction regulators with shunt and series transformers.

The induction regulator meets most requirements for distribution feeder-circuits. It requires about 8 to 11 sec. to go from full buck to full boost. One of the important factors in perceptible lamp flicker is the time required for the voltage to return to normal after a sudden change in value. For satisfactory service to lighting, it is important that fluctuating loads, which will cause sudden voltage changes at the feeder load-center, should not be supplied from the combined power and lighting feeder. They should be supplied from a general power feeder or from a special feeder entailing a consequent increase in distribution cost. Even general power feeders have connected to them resistance and motor loads which require close voltage regulation. If the fluctuating load is of sufficient magnitude, it would cause voltage changes at the sub-station which would affect the other feeders. Such voltage fluctuations would not be permissible and would prohibit connecting the load to the system.

Presented at the Annual Convention of the A. I. E. E., Edgewater Beach, Chicago, Ill., June 23-27, 1924.

The automatic tap-changing regulator has been used to a small extent for quick voltage adjustment. It requires about three seconds to go from full buck to full boost. It is limited in ampere capacity and voltage, it costs more than the induction regulator and has a high maintenance.

The synchronous booster is fast but expensive; it is noisy and has a high maintenance.

The saturated-core regulator can go from full buck to full boost in about one or two seconds, which is two to three times as fast as the tap-changing regulator and five to eleven times as fast as the induction regulator. While one or two seconds may not be a fast enough adjustment for some loads, it should be sufficiently fast to permit connecting most fluctuating loads, which previously required special feeders, to the regular feeders and connecting loads to the system which could not otherwise be connected. Where the tree-system of distribution feeder is used, the loads between the substation bus and the load center will still have voltage fluctuations. These fluctuations are due to the voltage drop from the substation bus to the load-center and for a given circuit the amplitude of the fluctuations depends on the proximity of the load to the substation. The load-center system of distribution eliminates this difficulty. Any loads connected to the same branch or mains as the fluctuating load are also subject to voltage fluctuations, the amplitude of which depends on the distance from the load center. Many important industrial loads which require close voltage regulation could be connected to mains other than the one supplying fluctuating loads. In other cases, it may be more economical or feasible to equip the industrial load with a saturated core regulator.

The saturated-core regulator is applicable to laboratory work where close regulation and fast operation are required to give a stable condition of voltage. A saturated-core type regulator was developed for the Mellon Institute of Industrial Research, Pittsburgh, Pa. to correct the voltage fluctuation of ± 6 volts occurring over their 110-volt supply. Very close regulation was needed in order to keep constant voltage on various heating units under tests.

The saturated-core regulator has higher losses and costs about 25 per cent to 50 per cent more than the induction regulator. It, therefore, might be used in place of the induction regulator only when fast adjustment is required or in high-voltage circuits. The saturated core regulator is still in a developmental stage and is not available for general commercial use.

Current-Limiting Reactor

The most frequent disturbances to which a transmission and distribution system is subjected are short circuits or heavy overloads which cause excessive currents, low frequency, and low voltage over the system. The effect over the system of these disturbances depends on the layout, extent, and capacity of the system and its protective equipment. The protective equipment consists first, of relays and oil circuit breakers to remove the faulty circuit from the system, and second, of series reactors or neutral grounding resistors to limit the amount of current flow into the fault.

The air-core type of current-limiting reactor is used in busses, tie lines, feeders and generator circuits, as

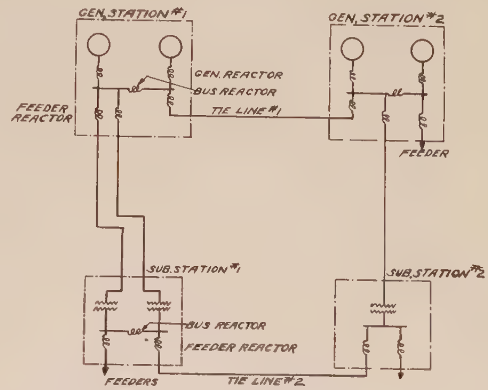

Fig. 1—Application of Current-Limiting Reactors to a Central Station System

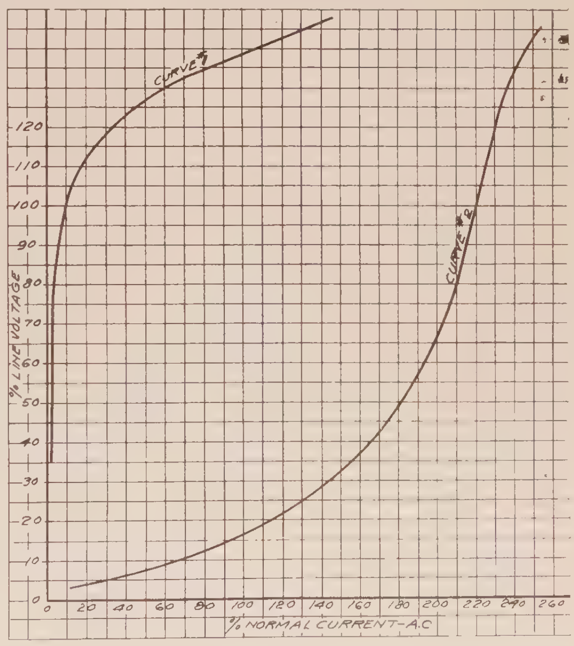

Fig. 2—Characteristic Curve of the Iron Core Reactor with and without d-c. Excitation

shown in Fig. 1. The voltage drop across the air-core reactor increases directly with the current flowing through it. The voltage drop across the iron core reactor increases directly with the current up to a certain point only, and then the voltage curve bends over as shown by Curve 1, Fig. 2. If the iron core reactor is magnetically saturated by the application of direct current, then the voltage drop across the reactor increases in a greater proportion than the cur-

rent between certain points as shown by Curve 2, Fig. 2. It is this characteristic of the saturated core type reactor which will determine its application in place of the air-core type reactor. The reactor can be designed with a ratio, of reactance under short circuit to reactance at normal load of 3 to 1, *i. e.*, if the normal load reactance is 10 per cent, the reactance under short circuit will be about 30 per cent. Three and one third times normal, then, would be the maximum current possible to force through the reactor at normal voltage of the system.

The change from normal value of reactance to short-circuit value is not instantaneous, but is similar to the time element of the synchronous reactance of an alternator under short-circuit conditions. Magnetic flux in the core cannot change instantly, but changes along an exponential curve of time. Approximately full reactance will be reached only after 0.08 to 0.16 sec. Since the reactance is not instantly available, the saturated core type reactor possesses no advantage over the air-core type reactor in protecting a system from the initial electromagnetic forces under short-circuit conditions. It does, however, reduce the current to be interrupted by an oil circuit breaker in series with the reactor, since the full protective effect is realized in a time shorter than the usual interval between the beginning of the short circuit and the parting of the oil circuit breaker contacts.

Current-limiting reactors are used in generator circuits of large modern generating stations, using the isolated phase arrangement of busses, to prevent a generator failure from being virtually a bus short circuit. They are also used in the circuits of generators of old design which will not stand short-circuit stresses. Bus reactors are used to sectionalize the main bus to limit the amount of power that can be transferred from a good bus section to a faulty bus section. Feeder reactors are used to limit the amount of power flow into a feeder fault. Limiting the flow of power into a fault by reactors reduces the duty on oil circuit breakers, the stresses and heating of busses, of cables, of current transformers and of disconnecting switches, and maintains the system voltage. Reactors in tie-lines between stations, substations and different systems are effective in limiting power transfer through the tie-lines under short-circuit conditions. They are particularly desirable where a small kv-a. capacity station, substation or system ties in with a large kv-a. capacity station, substation or system. The air-core type of current-limiting reactors successfully meets most requirements for generator, bus, feeder and tie-line reactors. In case the air-core reactor, to give the protection required, would cause too large a voltage drop under normal load, the saturated core reactor may then be substituted. In such cases, the saturated core reactor could be used giving approximately 33 per cent of the reactive drop of the air-core reactor under normal load. This type of reactor has several times the loss of the air-core type and a much greater cost, both of which will prevent its use except in special cases.

Application of the Saturated-Core Type Reactor to Station Auxiliary Bus

To improve the station economy and insure continuity of service house alternators for the station auxiliaries are operated in parallel with the main generators. The house alternator is usually of a lower voltage than the main generators and is usually connected to the main generator bus through house transformers. The power transfer through the house transformers may be from the main generator bus to the house service bus or vice versa, depending on operating and load conditions.

Certain auxiliaries such as boiler feed water pumps, circulating water pumps and motor-driven exciters are essential to the operation of the station and they must be protected from interruption due to system disturbances.

The effect of the system disturbances on the continuous auxiliaries can be reduced by dividing the house service bus into sections with a current-limiting reactor

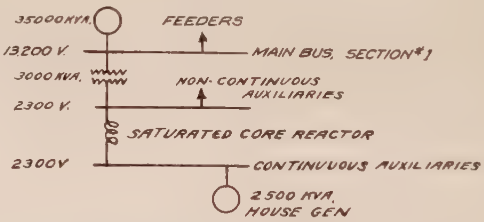

Fig. 3—Saturated-Core Current-Limiting Reactor Applied to Station Auxiliary Bus

as shown in Fig. 3. The house transformer and non-continuous auxiliaries would be connected to one section and the house alternator and continuous auxiliaries to the other section. The effectiveness of the reactor depends upon its ohmic value, the greater the reactance the less effect will the disturbance have on the house alternator and continuous auxiliaries. The reactor will not be required to carry the full kilovolt ampere output of the house generator or transformer and, therefore, may be designed for a smaller voltage drop than if designed for full output of either house transformer or generator. Even under this condition the ohmic value required will probably be so high that the voltage drop would be prohibitive. Therefore, the air-core type of reactor is undesirable for this service since its ohmic value is constant. The saturated-core type of reactor may be suitable for this service since its ohmic value increases with an increase in alternating current. The saturated core reactor would be designed for the required reactance under short-circuit conditions. The reactance under normal conditions could be about 33 per cent of the short-circuit reactance.

An installation of saturated-core current-limiting reactors connected similar to Fig. 3 is now in operation at the new Cahokia Station of the Union Electric Light & Power Co. near East St. Louis, Ill. The house transformers are rated at 3000-kv-a. and the house turbine at 2500 kv-a. The reactors are designed to carry 660 kv-a. under normal conditions at a 15 per cent reactance drop. The short-circuit reactance is approximately 38.5 per cent, which means that it is impossible to force more than 1710 kv-a. through the reactors at normal voltage. If the house generator should be carrying full load with 660 kv-a. flowing from the continuous bus through the reactors to the non-continuous bus, it would be impossible to add more than 1050 kv-a. or 42 per cent overload to the house generator in case of a disturbance on either the system, main generator bus or non-continuous bus. If it is required that the reactor shall carry the continuous auxiliaries in case of the house alternator failure, the reactor would have to be designed with less reactance but would not be so effective. This requirement may be best taken care of by oil circuit breaker and relay equipment which would shunt the reactor in case of house alternator trouble. Fig. 4 gives some idea of the general appearance and size of the reactors. Each single-phase unit requires 15.7 amperes, 125-volt d-c. excitation. The estimated total loss is approximately 7 kw. for each unit.

Fig. 4—Installation of Single-Phase Auxiliary Bus Saturated-Core Reactors at the Cahokia Station of the Union Electric Light & Power Company

Variable Reactance

The saturated-core reactor may be used as a variable reactance by varying the d-c. excitation. It is being used in this manner in transoceanic radio communication to modulate the antenna current of the Alexanderson alternator and to control the speed of the induction motor driving the Alexanderson alternator.

When used to modulate the antenna current the variable reactance is known as the "magnetic amplifier." It is inductively coupled to the antenna circuit by a special combination of tuned circuits. By this method the small current in the d-c. winding of the amplifier can be made to control a very large antenna current. The d-c. circuit may be controlled by a telegraph key or amplified telephone current. Because of its fast magnetic action it is well adapted to high-speed telegraphic transmission and to telephonic transmission.

When used to control the speed of the induction motor the reactor is connected in series with the motor primary leads. The d-c. excitation of the reactor is controlled by a voltage regulator similar to a generator voltage regulator. The voltage regulator is controlled by a rectified current from a tuned circuit connected to one of the coils of the Alexanderson alternator. The tuned circuit resonates at a frequency slightly above normal. When the antenna circuit is detuned by the magnetic amplifier, the alternator drops its load. In order to reduce the power input to the motor, after losing its load, the speed tends to increase but is checked by the action of the tuned circuit, the regulator and the reactor which reduces the voltage applied to the motor. Reducing the voltage applied to the motor reduces the power input to the motor to correspond with the light load condition at normal speed. A more complete description of the magnetic amplifier and speed-regulating equipment may be found in the *General Electric Review*, October, 1920.[1]

The saturated-core reactor could be used as a variable shunt reactance to control the lagging kilovolt-ampere required to counteract the charging current of very long, high-voltage transmission lines during light load conditions, but up to the present time they have seemed unnecessary as synchronous condensers are required to supply leading kilovolt-amperes under heavy load conditions and either inherently possess or can be built with sufficient lagging kilovolt-amperes to meet the requirements at little added expense. For example, a 250-mile 220-kv. transmission line requires at no load, 31,200-kv-a. lagging at the receiver end to maintain the receiver voltage equal in value to the generator end. For a 120,000-kw. unity power factor load 16,500-kv-a. leading is required to maintain the receiver voltage equal to the generator voltage. Some condenser capacity is necessary for correcting the load to unity power-factor which would be approximately 58,000-kv-a. for a 0.90 power-factor load. Then, the total condenser capacity required is about 75,000 kv-a. Three 25,000-kv-a. condenser units of normal design could supply 55,000 lagging kv-a. which is much more than is required for the no-load condition.

1. "The Transoceanic Radio Communication" by E. F. W. Alexanderson.

"The Alexanderson System for Radio Communication" by Elmer E. Bucher.

General Light and Power Supply of Chicago

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Review of the Subject.—*The development of a distribution system is largely determined by the load density and its rate of change. The following is a discussion of these factors and their influence on the Chicago distribution system:*

The d-c. system which supplies the central part of the city includes an area of about one sq. mi. in which the load is expected to reach 200,000 kw. in 20 years. This would economically require sub-station supply of about 10 substations of 25,000 kw. each.

Surrounding the small d-c. area the general light and power supply over the city is by means of 60-cycle, 4,000-volt circuits, except for the larger industrial loads which are supplied from 12,000-volt lines. The load density of the greater part of the 4,000-volt system is about 4,000 kv-a. per square mile, and the economical supply would be from 7,000 kv-a. remote controlled substations spaced about 1.3 miles. The maximum density of load on this system is 10,000 kv-a. which would require 10,000-kv-a. substations.

Calculations indicate that, with increasing load densities, the economy of this intermediate distribution voltage disappears, and in the ultimate development higher distribution voltages are necessary.

THE design of a distribution system for a city or community is naturally influenced by local conditions, such as the civic and architectural character, arrangement of streets, nature of load, construction costs, etc. Under the conditions existing, the development of a distribution system is then determined by the load density of a considerable area and its rate of change. The purpose of the following discussion is to describe the load distribution and density which influence the development of distribution systems in Chicago. The system discussed is for supply to general light and power and does not include that for railway or large units of power, which require special supply from the generating stations.

Energy is distributed by 4000 volt, three-phase, 60-cycle circuits over all of the area of the city for units of load up to 300 or 400 kv-a., except the "downtown" portion, which is supplied by the low-tension, direct-current network. Large single demands are supplied through individual transformer installations directly from the 12,000-volt, 60-cycle system.

Direct Current Distribution

The direct-current system at present covers eight square miles and distributes about 150,000 kw. maximum. About five square miles of the outer area of this system is being transferred to the a-c. system for better distribution economy, and to restrict the growth of the 25-cycle generating system which carries most of this load. The area to be cut over comprises about 20 per cent of the d-c. load and the density is about that of the more heavily loaded 60-cycle districts. The remaining area of three square miles in the congested business district will continue to be supplied from the d-c. network, because of the great investment in the existing equipment and the desire of some of us for battery reserve.

The design of the present d-c. distribution system, particularly in the congested areas, is limited by physical conditions, such as space available for distribution cables, sites, and capacities of substations available, etc., necessary to supply the demand. Of the total present load on this system, about 75,000 kw. is concentrated in about one square mile in the downtown loop district. Studies have been made of the demands, load, characteristics of the classes of business and their probable growth, to determine the future requirements of the distribution system.

About one-sixth of the area of the congested business district is covered by large retail stores, the average load of which, when developed with modern buildings, will ultimately be about 2500 kw. per square block. Most of the district is covered with large office buildings, hotels, and theatres. The modern office building load is about 2800 kw. per square block, and under the present permitted height of buildings may reach 6000 kw. per square block in certain locations where exterior flood lighting is also used. The modern large hotels average about 2800 kw. per square block, and the theatres about 1500 kw. Railroads and terminals now occupying considerable space in the downtown district will, after electrification, have high buildings above them, probably of the office building type with loads of 2800 kw. per square block. A small portion of the area is occupied by wholesale stores, warehouses, small manufacturing, etc., which will not average over 500 kw. per block. These demands for various classes of buildings with their diversities, indicate a possible load of 200,000 kw. in this square mile in the next twenty years. If such a system was being laid out new, with sufficient space available for substations and distribution feeders, the most economical supply would be from 8 or 10 substations of 25,000 kw. capacity, each distributing over a radius of two blocks. However, as there is not sufficient space in the average downtown street for the number of feeder cables required for the larger substations, it would probably be necessary to install 20 or more substations of smaller capacity. With this arrangement, 10 or more would probably be automatically-operated or remote-controlled from the remaining manually-operated substations.

60-Cycle Distribution

The 60-cycle, 4000-volt general light and power supply covers an area of about 150 sq. mi. and supplies 330,000 kv-a. over about 375 circuits of 1000-kv-a. capacity each. These circuits are operated radially,

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but are provided with emergency switching centers for the transfer of load between circuits. Customers whose load is of a special nature are being provided with supply from two circuits with oil switch throw-over. Feeders are practically all underground and primary and secondary distribution principally overhead from 22 attended substations of 10,000 to 20,000 kv-a. capacity and 19 remote control substations of 3000 to 6000 kv-a. capacity. The remote-control substations are supplied and controlled from the attended substations, and it is planned to make all future substations of this type. The rate of increase of load supplied by this system is about 18 per cent per year, and the detailed connections for its supply are continually undergoing changes in design necessary to provide for increased capacity and to improve economy.

The average load density is about 2000 kv-a. per sq. mi. and if uniformly distributed, the economical size of substation would be about 5000 kv-a. The maximum present load density is 10,000 kv-a. per sq. mi. and occurs in residence district solidly built up with high-grade apartment buildings, hotels, theatres, etc. The most economical size of substation to supply 4000-volt distribution for this density of load is about 10,000 kv-a. spaced about one mile apart. This capacity is also about the maximum unit of capacity of the present transmission cables. While at present only a few spots of comparatively small area have such dense loads, the present rate of increase and the development of high-class residence and hotel districts indicate an area of some 10 sq. mi. will have reached such density within a few years. Measurements made of loads of test blocks of various typical areas in the city over a period of years indicate the load density has, by no means, reached saturation.

The density of a very large part of the area served from this system is about 4000 kv-a. per sq. mi., and in general, the economical design of distribution circuits for this loading would determine the standard size and arrangement of circuits. Calculations show the economical size of substation is 7000 kv-a., spaced about 1.3 mi., and the economical size of feeder is 350,000 cm. This is influenced also by the decrease in the amount of feeder regulation required for the shorter and more uniform length of feeders, as compared with the original standard size of 1/0.

As the density increases, the economy of the 4000-volt intermediate system between the 12,000-volt transmission and the secondary distribution voltage is lessening. In the area of present maximum density of the system, there is a number of square blocks having loads of from 500 to 2000 kv-a. which could be supplied from a single transformer installation and secondary mains. The increasing number of such cases in these more densely loaded areas make it desirable to extend the 12,000-volt system into these districts, taking over the existing load in certain heavily loaded blocks, and as the load of the district, as a whole, increases, ultimately eliminating the 4000-volt system in the district.

Details of schemes for supplying secondary low-tension mains direct from the 12,000-volt system have been worked out and it is proposed to install 12,000-volt feeders of about 4000-kv-a. capacity, supplying transformers to be located in the vaults. These feeders are to be from the 12,000-volt attended substations and two lines brought into each vault with provision for automatically disconnecting a faulty line.

The cost of regulation is materially decreased by this scheme, as compared with 4000-volt distribution, where the entire load is regulated on practically every feeder. Regulation can be provided in the transformer vaults and usually would be necessary on only a small part of its total load.

Industrial power loads of 400-kv-a. or more are supplied at 12,000 volts from lines subsidiary to the 12,000-volt transmission system. These lines, where possible, are arranged in loops usually of 4000-kv-a. capacity from attended substations. There are a total of about 125 such installations with an average maximum load of between 500 and 600 kv-a. The loop arrangements offer a convenient and economical scheme where the customers are grouped, as they usually are, and provide means of protecting the general transmission system from interruption due to trouble on loops or in the customer's vaults, and at the same time providing the customer with two sources of supply, and automatic reserve in case of line failure. Current-limiting reactors are installed in the supply to the loops, to prevent an excessive rush of current into damaged equipment, and sections of the loops are controlled by relays, which automatically sectionalize or cut out a damaged link without interruption.

Another arrangement under consideration provides for two or more tap feeders to a group of customers, each one being provided with taps on two feeders with throw-over oil switches, automatically-operated. This scheme would require less switching equipment and often a more economical cable arrangement.

In general, the rapid increase in loads of central station companies during the past few years has made necessary radical changes in the distribution systems to meet the demands with the best possible economy. The problems of re-designing are often complicated by the large amount of investments already made and which must be used to the best advantage. The great increase in investment required for distribution makes necessary a continual and thorough study of the characteristics and rate of change of loads for some years ahead.

In accordance with the request of the Meetings and Papers Committee to shorten papers as much as possible the above is presented as some conclusions from detailed calculations. It is hoped that an opportunity will be given in the discussion to present the data on which they are based.

We appreciate that distribution systems in Chicago are in a transient stage and much study and a long sight ahead is necessary for their development. We recognize also with the increasing loads the tendency for higher distribution voltages.

New Type of High-Tension Network

An interconnecting System for the Supply of Electric Power over Large Areas

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Review of the Subject.—*The purpose of the paper is to present for consideration a new method of interconnecting sources of power and load centers in a large district with a well developed and well distributed load. The central idea is the superposition of a high tension network of single-circuit lines over the whole district for the purpose of supplying a medium in which current may flow in any general direction as changing conditions may dictate. This is similar to the underground network of the Edison Companies in the large cities.*

With a such a layout available, power anywhere in the district may be fed into the network and it may be taken out at any other point without serious loss of energy.

The network is connected directly to load centers as well as to existing generating centers and thus greatly assists the present distribution lines distributing power and also stabilizes the potential at each load center reached.

The charging current of the network may largely neutralize the lagging component of the load with favorable design.

A concrete illustrative network is worked out in considerable detail, covering the present load with an equal amount of new future load in the interconnected systems of Alabama, the Carolinas, Georgia and Tennessee, with a branch to the Appalachian Power Company in Virginia. The result shows a very effective, efficient and low cost system for this territory.

The plan is applicable to other districts as well.

Details are given as to the layout taken and the operating characteristics of the system.

Introduction

The purpose of the present paper is to propose a new type of inter-connection for high-tension networks for the economic supply of electric power over large areas having an already well developed load. No judgment can be formed on such a proposal without considering all pertinent factors, such as feasibility, cost, economy operating quality, technical design, etc.

There is a natural evolution in the development of the supply of power to any growing industrial district. In the beginning, supply centers start at favorable points, either sites for cheap power or favorable for advantageous load, and grow and spread until the district is fairly well covered with power systems, at least where the active industries exist. As these systems come in contact at their extreme points, they make connections and exchange power to their mutual advantage. In fact, one system may to a material extent depend on power from another system for supplying increments of its load as well as for emergency power.

There comes a point, however, as the load of the district grows, where the favorable sites for local power plants, especially water power, are exhausted in much of the district and resort must be had to local steam plants or more distant water power.

It will usually be the case that within any one such large district some few points will be much more favorable for the development of power in large blocks than other points, calling for the transmission and distribution of this power over the district. When this point is reached, a radical change in the nature of the interconnection and the general supply system is required. To propose a suitable system for such a situation is the object of this paper.

The point of view taken in the layout of the type of network proposed herein, is to utilize the transmission lines made necessary by the transmission of power from the most favorable sources of water or steam power in bulk, to serve at the same time to distribute this power over the district as widely as possible and to gain such other advantages as can be secured at the same time at small cost, for example, the improvement of voltage regulation and power factor.

The total advantage that can be gained over the trunk-line conception of interconnection, *i. e.*, using heavy lines between large power centers, is surprisingly great and can be realized only by studying concrete examples. In the paper following, these matters are gone into in some detail and a concrete example worked out to permit intelligent judgment to be made.

Part I

Special Features of the New Network

The underlying features of the new type of high-tension network, which is predicated on the combination of the supply of power from large central stations, located at the most favorable generating points, with the ready delivery of power at all points in the district where it may be needed, are the following:

Laying out the high-tension lines to reach as many substations at load centers as possible and using single

Abridgement of paper presented at the Spring Convention of the A. I. E. E., Birmingham, Ala., April 7-11, 1924; and at the Northeastern District Regional Meeting, Worcester, Mass., June 4-5, 1924. Complete copies, which are available to members without charge, contain considerable additional material bearing on operating control, control of voltage, method of installation, division of load between present and future lines, control of power factor, protective relaying and metering, etc.

circuit lines for this purpose, thus securing a true network.

Increasing the capacity of the distribution lines to deliver power in their own territory by feeding power back along these existing distribution lines from the various points of connection to the network, thus shortening the average local transmission and increasing the available feeds.

Establishing each point at which the high-tension network is connected to the existing distribution lines as a point of constant voltage, as well as a new center of distribution of high-tension power.

Utilizing favorably situated local power stations to stabilize the network voltage and to hold the established voltages fixed, regardless of the amount of or distribution of the flow of power and taking advantage of the slope of potential along a line with the prevailing direction of the flow of power to improve the line-power factor.

Co-ordinating the network voltage and charging current for any particular network to improve the power factor in the distribution lines and providing for control of line power factor at individual substations.

This high-tension network has the advantages of the low-voltage underground networks of the Edison Companies in large cities as far as efficient transmission and flexible distribution of power is concerned.

Typical Network

In order to make the value of this type of network more evident and to give a concrete example of how an actual installation would work out, a layout suitable for the Southeastern States, including Southern Virginia, North and South Carolina, Georgia, Alabama and Tennessee, has been worked out in some detail, but based on more or less arbitrary assumptions of load.

This network transmits new power, generated largely by hydroelectric plants, located in Alabama and Tennessee, to the amount of nearly 1,000,000 horse power, including 350,000 horse power from Muscle Shoals, and distributes it over the whole district, wherever it can be best used, this all being in addition to the present 800,000 or 900,000 horse power now generated. A large part of this load is located in the States of North and South Carolina, while the bulk of the power is generated far west of this.

To cover periods when water is low and steam must be used, a large steam plant is taken at the center of the system of the Appalachian Power Company in Virginia and another near Knoxville, where steam plant conditions are favorable. Furthermore, it is assumed that some power will be taken for general use from seasonal-storage reservoirs in a dry time.

It is expected that this amount of new power will be required by the growth of the district in from seven to ten years.

This network which operates on an average voltage of 190 kv. has a total line loss at peak load of about 11 per cent and also has satisfactory voltage regulation. The average $C^2 R$ line loss may be less than half of this, on account of the large portion of time when the load is light. Furthermore, the power factor in the distribution lines is raised to about 95 per cent on the average. As it happens, no synchronous condenser need be added in this layout. The capital cost, including transmission lines, high-tension oil breakers and step-down transformers, will be from $30,000,000 to $40,000,000 or from $45 to $60 per kw., delivered to the local distribution lines.

The actual locations of the high-tension lines, the load carried by each, and the new power taken from the network at each substation and generating point are shown in the accompanying map. The details of the layouts, will be found described at length in Part III.

Part II

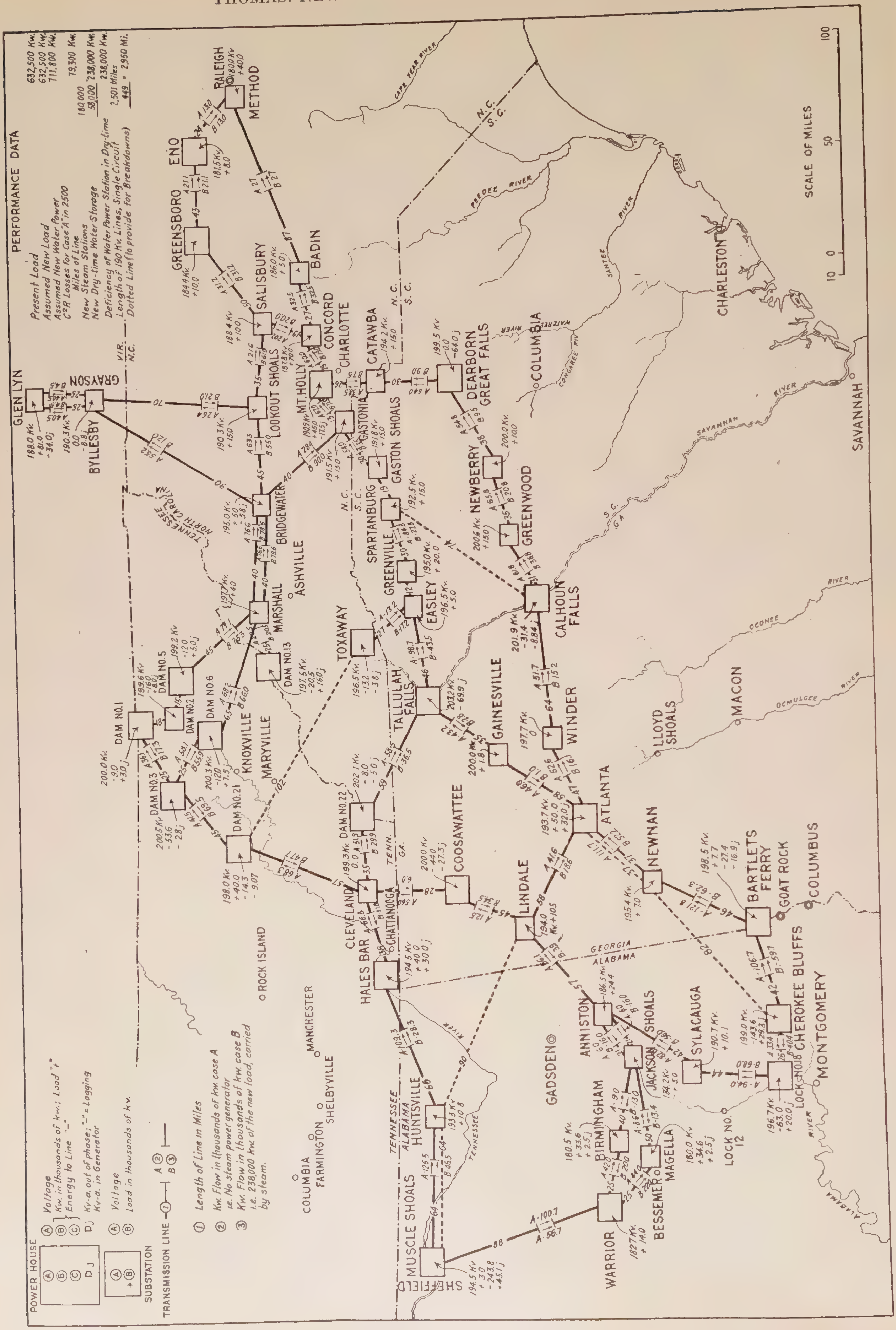
Advantages and Economies

In this section the advantages and economies of the 190-kv. network, shown on the map and described in detail in Part III, are discussed:

1. All the advantages of diversity, as applying to any interconnection, are obtained, such as daily-load-curve diversity, reduction of spare capacity, divergence between the differing periods of activity of different industries, either seasonal or due to swings of "boom-times" and "hard-times," railroad electrification, etc. also diversity due to difference in the dry periods of water power at different parts of the district. While it is beyond the scope of this paper to study this particular matter in a numerical sense, it may be pointed out that with a diversity gain of 10 per cent on the total peak output, here taken as 1,250,000 kw. on the 100-kv. lines, the additional power that might be sold would be 125,000 kw., with no additions to the general installation.

When the opportunity to reduce spare capacity is considered, it may well be that 10 to 15 per cent in the capital cost of generating units, power house, etc., may also be saved, at least in all new work. This may well amount to two to three million dollars in the final installations. This is in addition to the value of the above 125,000 kw. which may be worth from $2,500,000 to $3,500,000 a year; an amount sufficient alone to cover fixed charges on the cost of the network, transformers and high-tension breakers.

2. The fact that power generated at any point may be used at any other, without material loss and within any reasonable limit, with the advantage of unitary control for the system, would permit power to be sold considerably nearer the total water power available than with the component systems all operating separately. With this factor may be taken the material reduction in the continuous discrepancy between the growth of the load and the new generating capac-


POWER HOUSE
Ⓐ Voltage
Ⓑ Kw. in thousands of kw.; Load "+"
Ⓒ Energy to Line "−"
Dj Kv-a. out of phase; "−" = Lagging Kv-a. in Generator
SUBSTATION
Ⓐ Voltage
Ⓑ Load in thousands of kv.
TRANSMISSION LINE
① Length of Line in Miles
② Kw. Flow in thousands of kw. case A i.e. No steam power generator
③ Kw. Flow in thousands of kw. case B i.e. 238,000 kw. of the new load, carried by steam.
PERFORMANCE DATA
Present Load 632,500 Kw.
Assumed New Load 632,500 Kw.
Assumed New Water Power 711,800 Kw.
C²R Losses for Case "A" in 2500 Miles of Line 79,300 Kw.
New Steam Stations 180,000
New Dry-time Water Storage 58,000 238,000 Kw.
Deficiency of Water Power Station in Dry-time 238,000 Kw.
Length of 190 Kv. Lines, Single Circuit 2,501 Miles
Dotted Line (to provide for Breakdowns) 449 " 2,950 Mi.
GLEN LYN
BYLLESBY
GRAYSON
DAM NO.1
DAM NO.2
DAM NO.3
DAM NO.5
DAM NO.6
DAM NO.13
DAM NO.21
DAM NO.22
KNOXVILLE
MARYVILLE
MARSHALL
ASHVILLE
BRIDGEWATER
LOOKOUT SHOALS
SALISBURY
GREENSBORO
ENO
RALEIGH
METHOD
BADIN
CONCORD
MT. HOLLY
CHARLOTTE
GASTONIA
CATAWBA
GASTON SHOALS
SPARTANBURG
GREENVILLE
EASLEY
TOXAWAY
TALLULAH FALLS
CLEVELAND
CHATTANOOGA
HALES BAR
ROCK ISLAND
COLUMBIA
FARMINGTON
SHELBYVILLE
MANCHESTER
MUSCLE SHOALS
SHEFFIELD
HUNTSVILLE
COOSAWATTEE
LINDALE
GAINESVILLE
WINDER
ATLANTA
CALHOUN FALLS
GREENWOOD
NEWBERRY
DEARBORN GREAT FALLS
COLUMBIA
WARRIOR
BIRMINGHAM
BESSEMER
MAGELLA
GADSDEN
ANNISTON
JACKSON SHOALS
SYLACAUGA
LOCK NO. 12
LOCK NO. 18
MONTGOMERY
CHEROKEE BLUFFS
BARTLETS FERRY
GOAT ROCK
COLUMBUS
NEWNAN
LLOYD SHOALS
MACON
CHARLESTON
SAVANNAH
TENNESSEE
ALABAMA
GEORGIA
TENN.
GA.
N.C.
S.C.
VIR.
NORTH CAROLINA
TENNESSEE RIVER
SAVANNAH RIVER
OCONEE RIVER
OCMULGEE RIVER
SANTEE RIVER
PEEDEE RIVER
CAPE FEAR RIVER
WATEREE RIVER
CONGAREE RIV.
ALABAMA RIVER
SCALE OF MILES
10 0 50 100

ity installed, which is a material factor, getting greater as larger units must be installed. If these two factors aggregate 10 per cent it means another 125,000 kw.; if 15 per cent, 187,500 kw., which at $25.00 a kw. year and 10 per cent fixed charges, would cover to a capitalization of $30,000,000 to $45,000,000.

The advantage of the factors so far considered might be appraised also by considering that a plant of 75 to 80 per cent of the size otherwise necessary would be sufficient for carrying any definite load.

3. If the same quantity of power be transmitted by direct trunk-lines from the same water powers and steam plants to selected single points at the centers of the chief loads, about three quarters of the same mileage will be required for the actual transmission, but when the necessity for spare lines for individual trunk units is taken into account, it is doubtful if the trunk lines would not require more total length of circuit. This is because in the network properly laid out, very few links are long enough or important enough to require a spare. The delivery of this power to 35 step-down stations by the network system will thus cost no more for the high-tension lines than trunk-line distribution to a half dozen points. It should perhaps be stated that there may be all gradations between the two types of interconnections and that probably there is little likelihood that a trunk-line type pure and simple would be installed in this region.

To distribute the amount of power assumed to the 35 substations from the delivery points of the trunk lines would require perhaps 25 to 30—No. 0000 cable—100 kv. circuits, 50 miles long, aggregating with spares, 1500 to 2000 miles and costing $10,000,000 to $15,000,000. The necessity for this expenditure is largely avoided by the network and the delivery of power is made in a much more satisfactory and reliable manner. The statement here made must, of course, be based on averages and is largely of the nature of an estimate.

4. In the matter of voltage regulation, a very great advantage is secured by the network. In the first place, the voltage is stabilized at 35 load points, largely at points of distribution lines remote from their supply, and consequently with a naturally variable voltage. This means that the voltage at intermediate points on the distribution lines will be very materially steadied. Furthermore, with the power factor raised to 95 per cent in the distribution lines, the drop will be cut nearly in half. This improvement in the regulation is a major factor, but no effort is here made to give it a money value.

5. Perhaps the most important advantage of the network, shared only to a less degree by the trunk line transmission, is the opportunity to develop the most favorable power station projects to the exclusion of less favorable ones, which may happen to be nearer the load. If it be assumed that the large favorable sites may be developed for $30.00 a horse power less than local ones, this would mean for one half of the 1,000,000 new horse-power $15,000,000. This advantage may amount to a very much larger sum of money. As no such amount of local water power as 1,000,000 horse power is available, the absence of interconnection would mean local steam plants, adding 0.5 cents more or less to the cost of the power or the building of both steam power plants and part-time water-power plants, a still more expensive plan.

6. If the separate development of local companies means the addition of enough steam power with its higher cost to force an increase in power rates, with all the dissatisfaction that follows, and this can be avoided by the development of the distant water power, this factor alone would be of very great moment. As a matter of fact, this seems to be not an improbable contingency.

7. It is possible to concentrate a load of 100,000 or 200,000 kw. at almost any point in this system with only a small and local addition to the network. In case of war, this power could be secured by curtailing other uses, if necessary, at almost any desired points. This would be of extreme value in case of a war, since large amounts of power could be obtained at specific points and at very short notice, this power being drawn from any available supply at any point in the network. This would be useful in such work as the making of nitrates, poison gases or other special chemicals that might be required. During the late war the lack of any such quickly available large blocks of power greatly impeded the quick development of our war activities. In time of peace, the same thing could be accomplished, for example, by using secondary power, by power from the large Tennessee or Alabama storages, by operating steam plants or by adding additional generating capacity in small amounts wherever advantageous opportunities offer, such as completing plants in which provision has been made for future extension. 200,000 kw. of concentrated secondary power at $10.00 a year would be worth $2,000,000 a year, which would pay interest on the full cost of the network and step-down transformers and breakers.

It may be that a much larger amount of secondary power might be used.

8. An examination of the map will show that the flow of power can be in almost any direction in the district over favorable routes. The power from eastern Tennessee may go to the neighborhood of Charlotte, Virginia, Birmingham, or Atlanta. Muscle Shoals may send power to Charlotte, Virginia, Atlanta or Birmingham and similarly with the steam plants. This facility of the network is of a fundamental importance as it is not necessary to predetermine before installing a new station where the block of new power is to be used, as is the case with the trunk line system. If the center of load shifts greatly, no material disadvantage results.

9. The unitary control and the ability to distribute

large blocks of power in any direction over the network are of the greatest advantage. Where it is necessary to pass water over a dam when the local companies' load does not call for it, either at night or in the day time, the power of all such water can be absorbed in the larger system and the various reservoirs and pondages may be used to store water at other points. It may well be that new reservoirs could be added at favorable points for the specific purpose of saving energy in this manner. As far as the usefulness of the reservoir is concerned, it may be located at any point in the system without material disadvantage.

If it be determined to equalize the flow of the Tennessee River up to a certain point for purpose of navigation, this need cause no loss, since the power may be absorbed elsewhere as just stated.

10. With the trunk-line type of transmission, the steam plant must be at the receiving ends of the trunk lines, or if placed at favorable points for the generation of steam, additional and often long transmission lines must be installed. This is a most serious factor.

11. The supply of energy to new districts, which may be a little remote from existing lines, is easily provided, for the voltage here chosen is low enough so that step-down transformers and switches will be of reasonable expense, even for capacities as small as a very few thousand kw. The cost of tap high-tension lines, if layed out with this in view, can be made very reasonable. The network is so complete that for the district covered and a fringe of 50 miles wide on each side, the high-tension supply can be economically brought to any point.

Part III

Technical Basis of Network Performance

The discussion above has been based in part upon a definite performance of an assumed high-tension network, covering the Southeastern States. A statement will now be given of the basis on which this performance has been determined.

High-Tension Lines

The high-voltage circuits are single-circuit steel tower lines. The line conductor for each phase is composed of two or three cables strung side by side and electrically in parallel. Either two No. 0000 or three No. 00 aluminum cables, steel reinforced, can be made, if properly spaced, to give substantially the actual electrical line constants assumed. The limits of the present paper will not permit a discussion of the mechanical characteristics of such a line, interesting and important as they are. This is the resistance equivalent of about a 400,000 cm. aluminum steel cable or 85 per cent of the resistance of No. 0000 copper. The outside diameter of the equivalent cross section of two No. 0000 aluminum steel in one cable would be about 0.83 inch and the maximum voltage permissible for this single cable would be about 190 kv. However, the dividing of the conductor will raise the corona limit so that it will be well over 200,000 volts. This statement of the raising of the corona limit by the dividing of the conductor has both a theoretical and experimental basis. It will not be further discussed here. The line spacing is taken as 15 ft. average. While this is less than is sometimes proposed, this value is considered ample. One of the factors justifying the lesser spacing is the relatively tight stringing appropriate to the steel cove lines.

The electrical line constants used are as follows:

R = 0.23 ohms per mile equivalent conductor, of two No. 0000 aluminum cables.

Reactance = 1.59 ohms per mile × $\frac{2}{3}$ = 1.06 this being for one mile of two double cables, single phase.

(Allowing for a reduction of $\frac{1}{3}$ from the divided conductor).

Charging current = 0.267 × 3/2 amps. per mile = 0.4 per 100,000 volts for two double cables, single phase.

(Allowing for an increase of 50 per cent for the divided conductor).

Neutral dead grounded at each station.

Assumed Loading

As a starting point, loads were more or less arbitrarily assigned to about 35 substations in the territory covered and aggregating approximately the sum of the present peak loads of the companies now serving the district to represent the existing loads; this total comes to 632,000 kw. The list of stations and the load assigned to each is shown in Column 1 of the table. Capacities were then arbitrarily assigned to the principal *existing* generating stations, more or less representing their maximum outputs, in the aggregate appropriate for carrying the assumed loads. Capacity taken for the steam units is shown for the several stations in Column 2 and capacity for hydraulic stations in Column 3.

For the purpose of this study, it was then assumed that at the time supposed to be appropriate to the full use of the network, an additional or new load equal to the present would have developed at each substation, these new loads being shown in Column 4 in the table.

To supply the new load and transmission-line losses, it was assumed that new hydro stations would have been developed in the most favorable locations, these being shown in Column 5. The principal new plants are at or near Cherokee Bluffs on the Tallapoosa River and the big storage powers of the Upper Tennessee, together with Muscle Shoals and also Coosawattee. The general condition with the present power, carried by the present units in the present manner, together with the new 632,000 kw. carried by the new hydro-electric plants, but all connected with the same system, is called Case A.

As an alternative, to show a typical low water condition, with 238,000 kw. of the new load carried by

TABLE I—DATA FOR STATIONS IN THE NETWORK

					Case A		Case B			
	Normal maximum load—present	Rated steam power—present	Rated hydro power—present	Maximum new load assumed	New hydro assumed	Out of phase kv-a. at each power hse. + means leading in generator	Hydraulic storage taken equivalent to steam	New steam assumed	Deficiency of water assumed at dry time	High-Tension voltage; - maintained constant—in kv.
	1	2	3	4	5	6	7	8	9	10
STATIONS	Kw. and kv-a. values divided by 1000									
Carolina										
Badin	5			5						186.0
Bridgewater	5		25	5		− 5.8	10.0			195.0
Calhoun Falls					31.4	− 8.4			8.5	201.9
Catawba	15		230	15						194.2
Concord	7			7						187.8
Dearborn—Great Falls						−64.0				199.5
Easley	5			5						196.5
Eno	8	31		8						181.5
Gastonia	15			15						191.5
Gaston Shoals	15		22	15						191.8
Greensboro	10	8		10						184.4
Greenville	20	8		20						195.0
Greenwood	15			15						200.6
Lookout Shoals	15		21	15						190.3
Marshall	4			4						197.7
Method	40	3		40						180.0
Mt. Holley	45	45	70	45		−17.5				190.9
Newberry	10			10						200.0
Salisbury	10			10						188.4
Spartanburg	15			15						192.5
Toxaway					13.2	− 3.8			4.0	196.5
Virginia										
Glenlyn	81	60		81				90		188.0
Grayson-Byllesby			40							190.3
Alabama										
Anniston	24.4			24.4						186.5
Birmingham	33.6			33.6		+ 2.5				180.5
Cherokee Bluffs					143.6	+29.3			40.0	199.0
Huntsville	10.8			10.8						193.3
Jackson Shoals	5.0			5.0						184.2
Magella	34.6			34.6		+ 2.5				180.0
Mitchell Dam—Lock No. 18					63.0	+20.0			33	196.7
Muscle Shoals	3.0			3.0	243.8	+45.1			125	194.5
Sylacauga	10.1			10.0						190.7
Warrior	14.1	100		14.0						182.7
Georgia										
Atlanta	50.0	10	30	50.0		+32.0				193.7
Barletts Ferry	7.7	8.0		7.7	27.4	−16.9			12.5	198.5
Coosawattee					44.0	−27.3			15.0	200.0
Gainesville	1.8			1.8						200.0
Lindale	10.5			10.5						194.0
Newnans	7.0		150	7.0						195.4
Tallulah Falls						−69.9	15.0			203.2
Winder										197.7
Tennessee										
Cleveland										199.3
Dam No. 1					9.0	+ 3.0	23			200.0
Dam No. 2					16.0	+ 8.0				199.6
Dam No. 3					53.6	− 2.8		90		200.5
Dam No. 5					12.0	+ 5.0				199.2
Dam No. 6					12.0	+ 7.5				200.3
Dam No. 13					20.5	+16.0				197.5
Dam No. 21	40	9		40	14.3	− 9.1	5.0			198.0
Dam No. 22					8.0	− 5.0				202.1
Hales Bar	40	45	100	40			5.0			194.5
	632.5	339	854	632.5	711.8		58	180	238	

$C^2 R$ Line loss 711.800 − 632.500 = 79.300 Kw.
As per cent of power generated 12.5 per cent
As per cent of power delivered 11.1 per cent

steam plants, the conditions of Case B are set up, the locations and loads of the steam plants being shown in Column 8. These conditions are the same as Case A, except that the water power in certain of the new stations is assumed to be short in the aggregate amount of 238,000 kw., corresponding to the amount of steam power generated. The actual locations and amounts of water shortage assumed are shown in Column 9 in the table.

It is assumed that the simultaneous water shortage in the *present* plants is cared for at the same time by the *present* steam plants. It is believed that Case B here

assumed is more exacting on the network than the situation that would occur in actual service.

It is assumed that a certain amount of hydraulic power, taken above the normal high water requirements, will be drawn from two or three of the best seasonal storages, in lieu of an equal amount of steam power and this storage-water power is shown in Column 7 of the table.

New 100,000 kw. steam power plants are located at Glenlyn near the center of the Appalachian Power Company territory and near Knoxville in Tennessee.

The points at which the equivalent of steam power is taken from the storage are the following:

Bridge water	10,000 kw.	N. C.
Tallulah Falls	15,000	Ga.
Dam No. 1	23,000	Tenn.
Dam No. 21	5,000	Tenn.
Hales Bar	5,000	Tenn.

It is assumed that 100,000 kw. steam plant is located near Dam No. 3 on the Clinch River.

Voltage Control

It has been further assumed that the high-tension voltage at all regulating points; that is, all points where synchronous apparatus of important capacity and under control of the system operator is located, will be points of fixed voltage, regardless of load conditions and for dry or wet seasons, but that the particular voltage at any particular point may be chosen at any suitable value within certain limits, here between 180,000 and 200,000 volts, as may best fit the power-factor conditions in the line.

Power Factor of System

For the purpose of making a numerical calculation certain further assumptions were made.

1st. That the *new* load taken by the *new* network is at 80 per cent power factor, high tension.

2nd. That a lagging load will be taken at the load points, in addition to the above, sufficient to raise the power factor of the *present* load fed by the present distributing lines to 95 per cent.

As a matter of fact the charging current to the 190 kv. line will in the aggregate nearly neutralize the total lagging kv-a. of the load and transformers, but as the distribution of the lagging kv-a. and the leading kv-a. is different, the neutralization is far from complete.

Exception to the above assumptions was made in the case of Method and Glenlyn Stations where the lagging kv-a., taken by the high tension, was slightly less than the amount above specified.

Calculations of Performance

On the basis of the above assumptions, the actual voltage, current, kw. and kv-a. values were calculated for the whole system for Case *A*.

It would not be feasible to secure scientific accuracy in such a calculation as this with a reasonable amount of labor, but the voltages here given are believed to be correct within less than 1 per cent, except for two or three points where numerical mistakes have been found too late for correction. These errors, are however, not sufficiently important to materially effect any of the station quantities. The power actually flowing in the several lines is indicated in the transmission lines on the face of the map and are marked "*A*."

This calculation permits a determination of the total $C^2 R$ losses in the new network for this maximum load condition. The losses exclusive of corona or transformers are 79,300 kw. or about 12½ per cent of the delivered power and 11.1 per cent of the generated power for the maximum condition. The average year around losses would be probably about 35,000 kw. In this calculation no allowance is made for the saving in line losses in cases like the line from Atlanta to Tallulah Falls, where the current will tend to flow one way over a given route in the network and is now the other way in the present parallel distribution line. In such a case, of course, the oppositely flowing currents cancel, leaving only the difference flowing partly in one line and partly in the other. This will affect a large local saving in line loss on both lines.

In general, the use of synchronous condensers would greatly broaden the range of control of voltage and they may be necessary in some networks. In the present case, however, it is apparently possible to operate with constant voltages and reasonable power factors without condensers.

The change in conditions here assumed between Case A and Case B is the extreme and occurs only once a year and comes on gradually, giving opportunity for adjustment by changing taps, if necessary, as the change develops.

The effect of light load will be less difficult to handle than Case B for their out-of-phase currents are more effective, ampere for ampere, in correcting voltage slopes and there is ample machine capacity to handle them.

A high power-factor load, having the characteristics of decreasing to a lower power-factor load, as with induction motors, when off the peak, tends to hold the potential slope along the line relatively constant.

Relation of Network and Distributing Lines

Since the plan here proposed throws the generators, distributing lines and the low-tension network in parallel with the high-tension network between stations common to both networks, the method of control of the division of current between the high tension network and the distribution lines, *e. g.*, the present 100-kv. lines, should receive some consideration.

Part IV

Operating Features

The operating requirements of this system as they involve new or difficult features may be considered as follows:

Control

It is obvious that from a technical point of view and as far as day to day operating is concerned, the system must be under the absolute control of one dispatcher, at least as far as generators connected, field charge and governor adjustments, load carried, operation of all high tension connections, etc., are concerned. The maximum use of facilities further demand that control of water in rivers and reservoirs, the taking on of load and dropping of load where necessary should be under single control.

Power Distribution.

The distribution of power among the several generating stations is a fundamentally important one, for not only must the frequency be rigidly maintained but the dispatcher must be able to say how much load should be taken by particular machines so that water may be properly conserved.

Theoretically, the best results will be obtained from the point of view of the maintenance of frequency, by having a single station do all the regulating and setting all the others on a fixed gate and it may be that, as a matter of fact, one station may be able to regulate the frequency in this system. This will result, if the changes in load on the system as a whole occur so slowly that the load on the fixed gate machines can be adjusted rapidly enough to keep the proper margin for regulation at the regulating station. There are perhaps three or four stations or local groups of stations that could supply a regulating margin of 5 per cent which might be sufficient. This would mean, however, a large amount of idle apparatus at one point which would be undesirable, especially where there is no pondage to save water.

Furthermore, since governors of individual units must in any case be arranged so as to perform in consonance with others in a similar manner on load variations, they may about as well be in different stations. From these and other considerations, it is probable that the best plan is to have a single regulating station in each of the major systems, all with their governors carefully designed to be adjustable as to sensitiveness to changes (that is quickness of action); as to range of load change with change of speed; and as to normal speed. They may then be so adjusted that under operating conditions they will operate as nearly alike as possible. The setting of governors can be adjusted from time to time during operation, so that very close frequency regulation can be obtained. These regulating points should preferably be at the large storage reservoirs, so as to conserve water and to have water always available for regulating purposes. It is not likely that there will be any serious trouble on the distribution of load.

In this, account must be taken of the penstocks and water columns feeding the regulating generators but fortunately in this district there will probably be available in each system generators supplied directly from reservoirs and dams with very short water columns. It will do no harm to have a certain amount of variation in the sensitiveness of quickness of action of the governors, since the momentary overload capacity of the quickest acting will hold the frequency until the others catch up.

Instead of setting the machines which are not expected to govern on a fixed gate, their governors may be adjusted to have a wide range of speed with small changes in load. Then by changing the "normal" speed setting of the governor at the switchboard from time to time as conditions change, the load may be maintained at the prescribed value substantially as though with a fixed cut-off.

By this arrangement the following advantages are obtained:

a—Frequency will be maintained by a few specially sensitive governors, operating in stations selected as the most favorable.

b—Should anything happen to break apart the network, each sectional system would have its own system-regulating station and furthermore other local machines will come to the rescue of the regulating station on account of their wide speed range governors, above described, though with a slight drop in frequency, if the disturbance is very serious. In the case of a plant "importing" a large amount of power, it would be necessary to drop some load, if disconnected from the network at all points.

c—Regulation would be obtained without disturbing the economical use of stored water, for the *average* rate at which water is passed through the regulating station can be controlled at will by the load settings of the fixed-gate machines.

d—No very heavy blocks of power would have to be passed backward and forward over the network, as with change in load with regulation concentrated at one point system.

Favorable regulating points would seem to be

Bridgewater (with generating capacity enlarged)
Tallulah Falls,
Cherokee Bluffs (with the large storage developed)
Dam No. 3 including the large storage.

Reliability

Any general scheme of transmission and distribution must offer a high order of reliability of service. This proposed scheme is exceptionally favorable from this point of view. In the first place, a breakdown in any one transmission line link will affect only stations on this particular link, for no single link is essential to the network as a whole. The segregation of a single link is simplified because with the wide separation of power houses and the absence of large concentrated loads, no short circuit can occur in the network of a magnitude

to exceed the safe capacity of oil breakers. The single-circuit lines contribute to this result.

In the second place, since it is usually considered that with two circuits feeding a station, either circuit being able to carry the whole load, a reasonable degree of reliability is secured. Even if these circuits are on one tower, the network plan is especially well guarded, since any station is fed from two or more directions so that no cause affecting one supply line would also affect the other. In addition, most substations are connected to other stations by the low-tension distribution lines giving still another source of emergency power. With the trunk-line type of circuit a break in the line will affect a large amount of power and a number of stations.

Protective Relay System

At first thought the securing of a satisfactory relay layout for protection against disturbances may seem difficult, but this is not likely to be the case.

Notes on Mine Hoisting

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Electrically driven mine hoists have at last come into their own. For many years manufacturers labored with prospective buyers with little results. Long and laborious calculations were made, ratings determined with great accuracy, detailed specifications drawn and presented to the customer. He usually purchased a steam hoist. The good judgment of such a decision could hardly be questioned. The steam hoists had given good and dependable service for many years. The electric hoist was a new and untried device. Power lines were not as reliable as they are today. The mine shaft is the neck of the bottle and once this becomes plugged from any cause whatsoever, the output stops and the usual trouble ensues. Operators felt they had trouble enough with most shafts and would not consider a propositon, which to them seemed to have great possibilities for trouble, the remedying of which was beyond their control.

Some small electric hoists, however, were installed inside on comparatively unimportant slopes and considering the type of equipment, gave a very good account of themselves.

These hoists were equipped with series motors usually of the railway type. The control was very crude but fairly rugged. The first electric mine hoist of which we have any record was installed at Aspen, Colorado in July, 1888 and in 1895 at the same mine a 100-kw. generator was put on a hoist and run as a motor, this equipment being (so far as we can learn) the largest of its kind in this country and perhaps in the world.

Up to the year of 1910, we have records of the installing of only a few equipments of larger than 200 horse power for mine hoists. Following the year of 1910, the sales of electric mine hoists have had a very steady and healthy growth.

Many interesting and instructive papers have been published on the calculation of mine-hoist cycles. The general method of attack is the same; *i. e.* moments of the up and down loads per turn plotted and net moments or torque derived from the algebraic sum of these moments. The friction (assumed) and the acceleration and retardation moments are added with their respective signs and the final summation moment curve changed into horse power by substitution in the well known formula: horse power $= \frac{2 \times \pi \times \text{r.p.s.}}{550} \times M$

It is not by any means the object of this short paper to enter into calculations of the cycle, but rather to show some results that have been obtained from actual installations which have been designed to meet such calculated cycles.

Many records are obtainable where the kilowatt hours per trip have checked accurately with the estimate figure given by the electric manufacturer at the time of sale. It is often very difficult to get data wherewith to check this figure as many hoists are run for other purposes than hoisting ore. In coal mines, rock is often hoisted and men and material are handled in the main shaft. So kilowatt hours taken by the hoist include much other work than actually hoisting coal.

The Lehigh Coal & Navigation Company have a water hoist which was installed some years ago. The bucket lifts 30,000 lb. of water per trip through about 865 ft. at a rope speed of 1100 ft. per min. The winder is driven by a 1200-horse power a-c. motor. An accurate record is kept of the number of buckets hoisted and nothing else is handled on this hoist.

Over a year's run, the kilowatt hours per trip on this hoist checked exactly with the figures given by the electric manufacturer, the actual figures on this hoist being 15.5 kw. hr. per trip or 1.2 kw-hr. per 1000 ton ft. This is an exceptionally good figure, better than the average. On short, fast cycles, the kw-hr. per 1000 ton ft. may run as high as 1.9.

Presented at the Spring Convention of the A. I. E. E., Birmingham, Ala., April 7-11, 1924.

Incidentally, it is impossible for the electric manufacturer to give a customer any positive guarantee as to the kilowatt hours per trip or per ton. This figure depends upon a number of conditions beyond the electric manufacturer's control.

The mechanical efficiency of the winding engine proper is somewhat of a guess. The rope and guide friction are variable quantities. In fast hoisting, windage must play a small part at least, and just as the sum of these quantities differs from its assumed value, so will the final result differ from the calculated.

During the last ten or fifteen years, a large number of very fast electric mine hoists have been installed, using the well kown Ward-Leonard control with or without flywheel equalization as the conditions indicate. Many of these hoists have cylindro-conical drums with very steep pitches up the cone. The duty cycles for these equipments have been calculated in the usual manner and have shown in many cases quite excessive acceleration and retardation peaks after the rotating parts had reached full speed, due to the acceleration of the up-load up the cone and the retardation of the down-load down the cone. These peaks many times produce a cycle with very jagged and irregular shape. It was, of course, fully realized that these peaks in actual practise must smooth themselves off because the system, due to the flexibility of the ropes, is far from rigid.

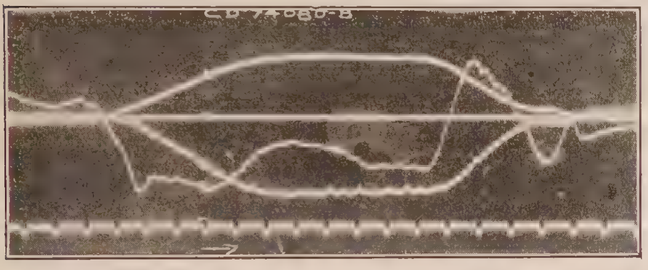


Fig. 1

So far as the authors know, no reliable test had ever been taken on a Ward-Leonard control system using very rapid recording instruments, such as an oscillograph so that the actual shape of the duty cycle was more or less a guess, though we felt the area could not differ very greatly from the area of the calculated cycle. In view of the absence of such data, it was decided to run a complete test on a fast Ward-Leonard equipment and determine how close the calculated cycle and the actual cycles were checking.

The Old Ben Coal Corporation, of Chicago, have in their Southern-Illinois mines several Ward-Leonard flywheel equipments, some of which are operating on very fast cycles. It was decided that if this Company would permit us to inconvenience them to the extent of making a test on one of their equipments, all the data necessary would be obtained. The matter was taken up with the Old Ben officials and their hearty cooperation was very gratifying, they extending us every possible courtesy and assistance in the preparation for the tests. Their No. 18 mine was selected as being a very fair example of fast hoisting.

The equipment at No. 18 Old Ben mine consists of the following:

1 d-c. hoist motor rated 950-horse power 40-deg. 65-rev. per min., 400-volts, direct connected to a cylindro-conical hoist drum having a small diameter of 7 ft. and a large diameter of 11 ft. with four turns up the cone.

1 Flywheel motor-generator set consisting of:

1 750-kw. 900-rev. per min., 400-volt generator

1 700 horse power 900 rev. per min. 2200-volt 3-phase 60-cycle induction motor.

1 19 kw. 900-rev. per min. 250-volt, compound-wound exciter and a steel plate flywheel, 92 in. in diameter, weighing 19,300 lb.

1 Control equipment consisting of:

1 Slip regulator with torque motor for controlling the speed and input to the flywheel set

1 Drum controller and field rheostat for controlling the speed and direction of rotation of the hoist motor by means of varying the generator voltage.

This equipment was designed to operate under the following conditions:

Weight of coal per trip	10,000 lb.
Total distance hoisted	335 ft.
Weight of cage	15,000 lb.
Type of cage—self dumping	
Weight of mine car (open end type)	4,300 lb.
Rope diameter	1½ in.
Weight of rope per foot	3.55 lb.
Turns on small drum diameter	2.71
Turns up cone	4
Turns on large diameter	4.7
Time for acceleration	5 sec.
Time at full speed	5.5 sec.
Time for retardation	5 sec.
Rest period	4½ sec.
Trips per minute	3

From observation it was found that in adjusting the ropes on the drum, the active turns on the small diameter did not check exactly with the turns originally decided upon, the active turns on the small diameter being found to be 1.9. This, of course, materially affects the shape of the duty cycle, since the rotary acceleration and the acceleration due to climbing the cone would overlap each other slightly. Fig. 6 shows this clearly.

Using the conditions as they exist, a duty cycle was calculated in the usual manner and this cycle compared with the cycles obtained from the test. In addition to the conditions of winding the rope on the drum being slightly different from that originally calculated, the coal loads, as is always the case, differed somewhat from the calculated load in that no particular car during the actual test carried exactly 10,000 lb. of coal. The

nearest approach to this, from a long series of tests, was a car containing 9,500 lb. and this value and the number of observed turns as above stated were used in making up the calculated duty cycle for checking the test results. For the purpose of simplicity, this single cycle will be discussed.

During the test, the following readings were taken:

Direct current between hoist motor and generator (oscillograph)

Voltage at motor terminals (oscillograph)

Motor speed in rev. per min. (oscillograph)

Kilowatt input to motor generator set (graphic wattmeter)

Speed of the motor-generator set (graphic volt-meter)

Time in seconds (oscillograph and timer on both graphic charts)

Weight of coal hoisted.

Fig. 1 shows the oscillograph curves as above described. The rev. per min.-curve C in Fig. 1, was obtained by a pilot generator with constant excitation belted to the hoist. The saw-tooth effect shown in this curve is undoubtedly due to the commutator bars passing under the brushes. The current curve B and the voltage curve A were read directly on the oscillograph in the usual manner.

Fig. 2 shows the input to the motor-generator set during the cycle under discussion.

The speed curve of the motor-generator set for this particular cycle is not available, as the pilot generator belted to the motor generator set gave trouble at this particular moment. Other tests, however, showed that the slip of the motor generator set during the hoisting cycle is slightly less than that originally calculated.

From the above test readings by the application of the proper constants, it is not difficult to make up the actual horse power curve showing the horse power input to the hoist motor. Also as described early in the paper, a duty cycle was calculated, using the turns and weights as they existed. These two curves are plotted and shown in Fig. 3. The dotted line is the calculated duty cycle, and the heavy line the actual test results. The areas of the two curves check surprisingly well, the difference being less than 2 per cent.

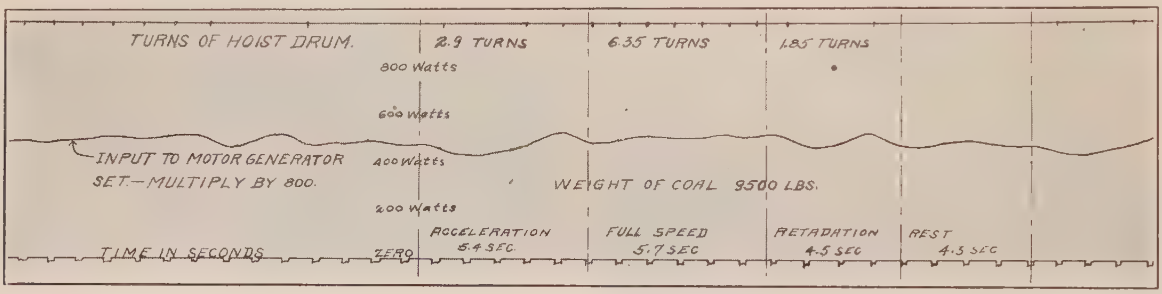


FIG. 2

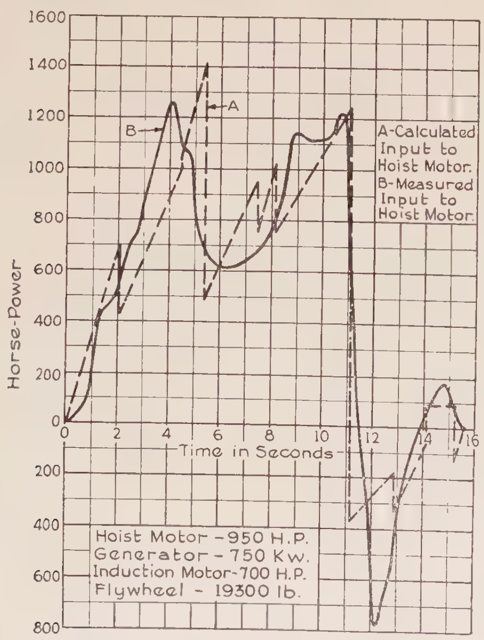


FIG. 3

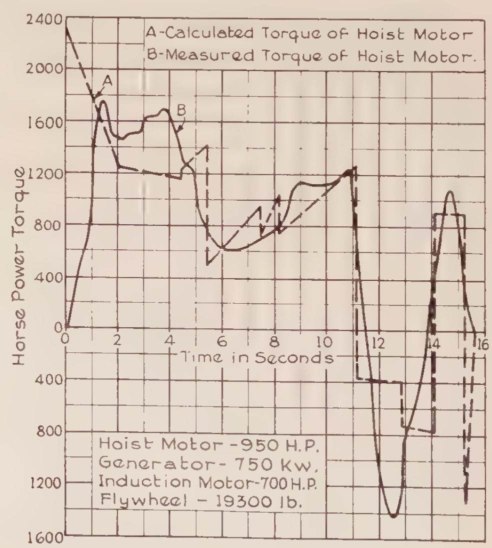


FIG. 4

It is interesting to note how the acceleration and retardation peaks, due to the effect of the cone, are more or less smoothed out in actual practise. This undoubtedly is because of the stretch in the rope. The

most noticeable variations in the test cycle from the calculated cycle occur during acceleration and retardation. This may be due to quite a number of causes. The drums and rotating parts may be slightly heavier than assumed in the original calculation; and as will be seen from the speed curves, the rate of acceleration changes while the calculated duty cycle assumes a constant rate of acceleration of the rotating parts.

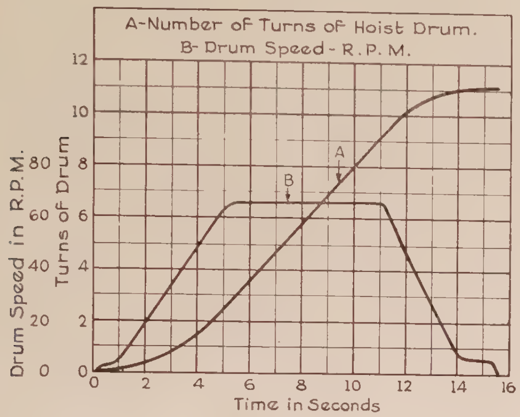


Fig. 5

Fig. 4 shows the calculated torque as compared with the torque obtained from test. Here again, we find some slight differences, the most interesting among which is undoubtedly the fact that it takes a very appreciable time for the current to build up to the necessary accelerating value; whereas in the calculations, it is assumed that this current goes instantly to the value necessary to produce the required torque.

Fig. 5 shows speed curve of drum in rev. per min.

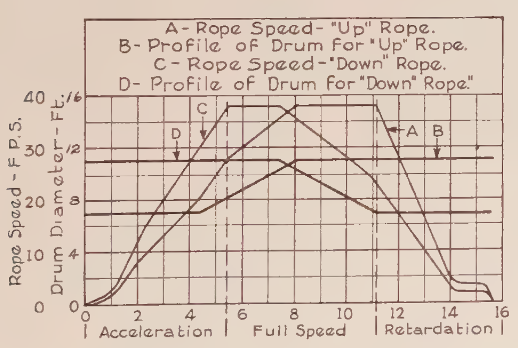


Fig. 6

against time and also total number of turns of drum against time. It is interesting to note how the rate of retardation changes, first being very high, then falling to zero and running at practically constant speed for about a second and finally retarding to rest at a high rate. This retardation curve is not determined by any automatic devices, but is the result of the operator's experience in handling the equipment. Incidentally, curves were taken with different operators handling the hoist and in each case, the same general result is observable.

Somewhat the same general characteristics are observable during acceleration. The acceleration rate in the beginning is low, then increases and remains at a practically constant rate for about four sec., then falls off somewhat gradually until constant speed is reached.

These curves are undoubtedly very interesting to a manufacturer, but what the customer is particularly interested in is the input from his line which represents to him actual expenditure. The kilowatt hours consumed in hoisting 9500 lb. through 335 ft., as indicated on the graphic wattmeter chart, amounted to 2.25 kw-hr. per total trip, including the rest period or 1.41 kw-hr. per 1000-ton ft. The calculated input to the induction motor in kilowatts indicated 412 while the average reading from the graphic chart showed 402.

The calculated overall efficiency figured from actual foot pounds of energy consumed in the shaft to input to the flywheel set showed 52.4 per cent while the actual efficiency from the test showed 53.4 per cent.

CORRESPONDENCE

A. I. E. E. PUBLICATIONS

To the Editor:

It has been said, somewhat frivolously, but with a large amount of truth, that an engineer is a man who can do for a dollar what any fool can do for two dollars. This means that one of the chief characteristics of an engineer is efficiency.

In the JOURNAL of the A. I. E. E. each month there is a great deal of information, all of which is valuable and interesting, but not all of which is of a great deal of interest to any one individual. This is true on account of the specilization which exists today.

It is also true that many papers which are prepared by members of the Institute and read before various sections are not published on account of lack of space in the JOURNAL, even though they may be of interest to a large number of members.

I suggest in the interest of efficiency and of economy that all papers be printed as pamphlets and that the JOURNAL as published each month consist largely of abstracts of all the papers which are printed. Individual members can then write to the Secretary requesting copies of papers in which they are interested, which may then be sent to them gratis or for a nominal amount. The shelves of individual members would thus not be filled with a publication which however valuable in itself can, in the nature of things, be of value only to a relatively small percentage of its total volume to any individual man, and conversely, the individual member will have in his library copies of papers in which he is vitally interested, many of which are not available under present circumstances.

I feel very strongly that this policy would present very decided advantages over the present publication policy, and trust it may be given serious consideration.

Yours very truly,

SIDNEY WITHINGTON, *Electrical Engineer.*

Automatic Substations for Supplying 1500 Volts
Direct Current to Suburban Railways

BY C. A. BUTCHER

Member, A. I. E. E.

General Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Review of the Subject.—*The engineer in applying automatic substations to an existing electrified traction property is often forced to make the most of a poorly designed or antiquated distribution system. By comparison, the problem of designing the distribution system for the electrification of a steam railroad is often very simple. The choice of proper converting equipment is perhaps not so easily made. The author brings attention to a number of important points which should be given careful consideration by those contemplating electrification.*

* * * * *

IN Europe and in one instance in America, 1500 volts direct current has been selected for the electrification of the suburban traffic of steam railroads operating in a number of the larger metropolitan areas.

The operators of these steam railways have set and maintain very high standards of operation. If electrification is to be justified, it must be on the basis of even better service and greater economy of operation.

The steam locomotive is an extremely reliable isolated power plant. The percentage of train delays due to locomotive failure is low. The failure of one locomotive on a steam-operated suburban road would probably delay traffic by an amount insignificant by comparison to the delay which might result from failure of power supply to an electrified system.

Perhaps one of the most important links in the power system is the substation. If the substations are designed and equipped with the same degree of care as our large modern steam-electric and hydroelectric generating stations, they will be equally reliable in operation and so leave little doubt that continuity of power supply will be comparable with steam locomotive operation.

Considering substation requirements, very careful thought must be given to the following:

1. Present and future total power requirements.
2. Location of substations.
3. Capacity of substations.
4. Selection of converting equipment.
5. Voltage and frequency of a-c. supply lines.
6. Number of a-c. supply lines to each station.
7. Selection of switching equipment.
8. Scheme of control for the operation of d-c. feeder circuits.

Power Requirements

The present power requirements of any given system may be readily calculated from an analysis of train schedules, train weights and a profile of the routes followed. Future power requirements may ordinarily be anticipated by an analysis of records to determine the average rate of increase in traffic.

Power requirements with reference to the entire system are made up of three principal elements, *viz*; total energy required, power at peak load and load factor.

The characteristics of a suburban railway are ordinarily such that the characteristics of each section of the system are similar. This will be noted from a study of train sheets and load curves. Therefore, the power requirements of the average substation which supplies some given section, will ordinarily be quite similar to those of the system as a whole. However, by studying the requirements of separate sections individually, those elements which enter for special consideration can be readily taken care of in laying out a substation or a group of substations for each section. For example, the load curve of a terminal substation will differ somewhat from that of an intermediate station. Also, holiday loads which come infrequently and which may be peculiar to some particular section of the system, may have a very decided influence on the required substation layout.

Substation Locations

The proper location for a substation is sometimes quite obvious. Also, physical limitations may often determine the substation location. The number of substations will ordinarily be determined by an economic study to determine both the fixed and the variable operating charges.

Capacity of Substations

The capacity of the substations should be sufficient so that any one substation or any unit in any substation being out of service would not interfere seriously with the maintenance of regular train schedule.

The number of units as well as the type and nominal rating of the units required in each station will be determined by a study of the average load, peak load and load factor. Since the load factor of the average suburban railway is probably less than 35 per cent, the substations will be equipped with more and smaller units than would be used if the load factor was higher. This permits of operating the machines in service on light loads at the most efficient loading. Increase in load is taken care of by putting additional machines into service.

Presented at the Annual Convention of the A. I. E. E., Edgewater Beach, Chicago, Ill., June 23-27, 1924.

The average suburban train under acceleration requires from 300 to 500 kw. per car as compared to an average power requirement of perhaps 100 kw. per car. Should the train schedule be such that eight car trains, for example, are operated on a 15-minute headway, the substations would be designed to meet the peak requirements rather than average requirements. In other words, the commutating capacity required will determine the size of the substation unit.

Selection of Converting Equipment

In cases where the operation of synchronous converters is known to be entirely satisfactory, there is ordinarily little reason for considering motor-generators. If converters have not been operated under the conditions contemplated or known to exist, consideration must be given, especially to the probability of the frequent occurrence of such disturbances as those to which converters are inherently sensitive. Motor-generators should be used instead of converters on the end of long transmission lines where the voltage is subject to sudden fluctuations, such as surges resulting from switching operations or sudden changes in load. If synchronous condensers are used to regulate the voltage, the operation of synchronous converters will be quite satisfactory. If the resistance drop in the transmission line is excessive, the operation of synchronous apparatus in general will not be satisfactory.

Where the a-c. supply is to be at 13,200 volts or less, the comparison with converter must be made with converter and necessary transformers considered as a unit. Above 13,200 volts, transformers are required with motor-generators which gives decided advantages to the converter in the items of efficiency, space requirements and weight. In the smaller sizes, however, up to and including 1500 kw. at 13,200 volts, the installations of synchronous converters with automatic switching are about on a parity with the installations of synchronous motor-generators with automatic switching. With the transformers on the same floor level, there is little difference in space required. There is little difference in the first cost for equipment in capacities from 1000 to 1500 kw. The overall efficiency is in favor of the converters.

The restricted capabilities and less favorable design characteristics of the 50 and 60 cycle converter may logically be expected to show up when the maintenance expense is compared with that of the motor-generator. The great majority of the maintenance expense items is incident to the operation of the current-collecting parts of the machine. A converter, with its added collector rings, will require maintenance expense for both current-collecting elements. Due to less favorable commutating characteristics and closer spacing of all brush parts, the life of the brushes will be very much less than that of the motor-generator. Flash-overs are very severe on the brush life and the most favorable unit in this respect has a great advantage from the standpoint of maintenance expense. The relative length of time that each type of unit is available for service is also an excellent guide as to the relative maintenance expense that is to be expected.

Every synchronous machine has a definite pull-out load. The synchronous machine carries load by virtue of its rotor "dropping back" in phase position sufficiently to pass the necessary load current through the impedance of its internal circuit. On large 60-cycle converters, approximately seven times full load causes the rotor to drop back sufficiently to pull out of step or slip a pole if the load is not removed in a sufficiently short time interval. Obviously, pull-out will occur at much lower load values as the a-c. supply voltage is reduced. A synchronous commutator-type machine cannot slip a pole under full voltage at the commutator without very serious flashing. To prevent flashing under these conditions, a quick-acting circuit breaker must operate to relieve the converter of its excessive load before it can drop back to its pull-out position. If the resistance of the short circuit path, including the resistance of the converter windings, is such as to limit the current to less than this figure, high-speed breaker protection is not required. Such equipment or such circuit resistance is essential with any arrangement of converter, if interruption to service from short circuit is to be prevented. In a 1500-volt system, the short-circuit current will not ordinarily be limited sufficiently by the resistance of the short-circuit path so that the high-speed circuit breaker protection must be considered as absolutely essential. There is always a contingency that the protective device may be inoperative, that the short circuit may occur inside of the protective device, or that the flash-over may be caused from disturbances in the high-tension supply. In any case, the converter must be removed from service until repairs are completed. The insurance of continuity of service on converters is obviously less than with motor-generators.

The motor-generator, as has been proven by the installations on the electrified sections of a number of steam railroads, has the inherent capability of withstanding without serious injury, such short-circuit conditions as are met with in service without any special protective devices. The motor-generator, because of more conservative design characteristics, when compared with standard railway converters, may be relied upon to carry 300 per cent load in daily duty cycle as against 200 per cent peak load on 50 and 60-cycle converters. If this short-period peak-load requirement met with in the acceleration of heavy trains, detemines the size of substation required, it is evident that 50 per cent more converter capacity will be required to meet the service conditions than if motor-generators are used. This difference in the momentary rating of the two types of equipment should be given serious consideration in making any comparisons in the sizes of substation equipment required for

this service. The motor-generator also has sufficient mass in its rotor to prevent it being pulled out of step by a short circuit which is relieved by any circuit breaker of ordinary speed.

Shunt and Compound Wound Converters

In applying synchronous converters to electric railway service, the characteristics of both shunt and compound-wound machines should be considered. The compound-wound machine, due to its flat voltage characteristic, has generally been considered best for all classes of electric railway service. In the case of automatic substations supplying power to a system designed for heavy service and with inherently low ohmic resistance per unit length of circuit, shunt-wound converters have decided advantages. These machines, when used with transformers of from 5 to 7 per cent impedance, instead of 15 per cent as used with compound-wound converters, have a drooping voltage characteristic, the regulation being on the order of 5 per cent. In multiple unit stations, no equalizer is required, and for this reason the automatic control is considerably simplified. If, due to congestion of traffic, one station is overloaded, the resultant drooping voltage causes adjacent stations to pick up the load in proportion to the trolley bus voltage. A congestion at one point means light load at adjacent points, and therefore, capacity required for the necessary assistance to the overloaded station is available. In stations where compound-wound converters are used, this drooping characteristic has been effected by limiting resistors being inserted in the circuit by the opening of shunting contactors controlled through the contacts of overload relays. These resistors must be of low ohmic value and of high thermal capacity and must be shunted normally by contactors capable of carrying current equal to one and one half times the nominal full load of the converters for the guaranteed overload period of the machine. In stations supplying heavy suburban service, at least two steps of resistance for each machine are required. The cost of such equipment is obviously high. In addition, the cutting in of the resistance causes a sudden drop of load. If a shunt-wound converter is used, but one step of current-limiting resistance together with its shunting contactor is necessary to provide against a very severe overload. Normally, the inherent voltage drop is sufficient to prevent overloading beyond the short-time overload capacity of the unit. The drooping characteristic of the shunt machine may be compared with that of the compound machine and limiting resistance shunted by contactors in an infinite number of steps so controlled as to increase the value of effective resistance to prevent increase in load above a predetermined maximum. The resistors for use in automatic substations and especially with compound-wound machines must be very carefully designed in order to prevent the shifting of an excessive amount of load to adjacent stations, so as to set up a condition under which the machine might be first underloaded and then overloaded, due to the opening and closing of the resistance shunting contactors. This "pumping" of the load back and forth between stations is impossible with shunt-wound machines, each of which at all times, due to the drooping characteristics, tends to shed the load.

Voltage and Frequency of A-C. Supply Lines

There is often no choice of the frequency of the power supply available, since this is usually fixed by other factors over which the railway companies will have no control. In general, 25-cycle synchronous converters operate more satisfactorily than 60-cycle converters. However, the 60-cycle converter has been so developed as to give highly satisfactory performance. 25-cycle transformers and converters are somewhat higher in first cost and occupy more space per kw.

The high-tension a-c. supply voltage to be used is determined in most cases by the distance over which the power must be transmitted. However, in comparing the cost of a number of voltages which may be used, serious consideration must be given to the fact that the cost of high-tension switch gear, lightning protective apparatus, etc., required for the substations will be greater with the higher voltages.

Number of A-C. Supply Lines to each Station

Each substation of an important suburban railway should be supplied by no less than two a-c. circuits, if the feeders are of the radial type or by a loop system on which power may be supplied from either or both directions normally, or from one direction or the other in case of failure of some part of the loop line. A single feeder may be of insufficient capacity to supply a large station, in which case two or more would be required. If two feeders are required normally, it is quite obvious that at least three supply lines should be installed if continuity of service is to be assured.

Selection of Switching Equipment

A great deal has been written regarding the economies effected by automatic stations. These are mostly concerned with savings in attendance charges and reduction in power losses. The operating records of automatic stations, show that by comparison with purely manually-operated stations, power failures are greatly reduced. Consider for example, a failure of the a-c. power supply. Within less than a minute following restoration of power, an automatic substation is completely restored to operation. Depending on the capacity of the units, the agility and alertness of the operator, and the general layout of the equipments, a manually operated station could be restored to service only after a comparatively much longer period.

The automatic switching equipment of a railway substation is designed so as to keep the machine on the

load when it is needed. Should the station be subjected to heavy overloads, either the drooping characteristic of shunt machines or current-limiting resistors, which are automatically inserted in the circuit between the d-c. terminal of the machine and the feeder bus, cause a reduction in bus voltage to force adjacent stations to pick up a portion of the load. Thus, where a manually operated unit, not equipped with the limiting features, would be "knocked off" the load by the tripping of the machine breakers, thus causing an interruption of power, an automatically-controlled unit would merely back away from the excess overload and "stick" to the limit of its capacity.

It has been demonstrated that this feature of "wiping off" the load peaks permits the use of smaller units to handle service characterized by periodically recurring peak loads. Thus, a converter or a motor-generator in an automatic railway substation may be applied more nearly on the basis of its nominal rating than in a purely manually-operated plant which would necessarily be designed to take the entire peak-load swings.

The larger units for 1500-volt d-c. railway substations, whether motor-generators or converters, will for the most part, be made up of two 750-volt machines connected in series. This is especially true of 50 and 60-cycle synchronous converters.

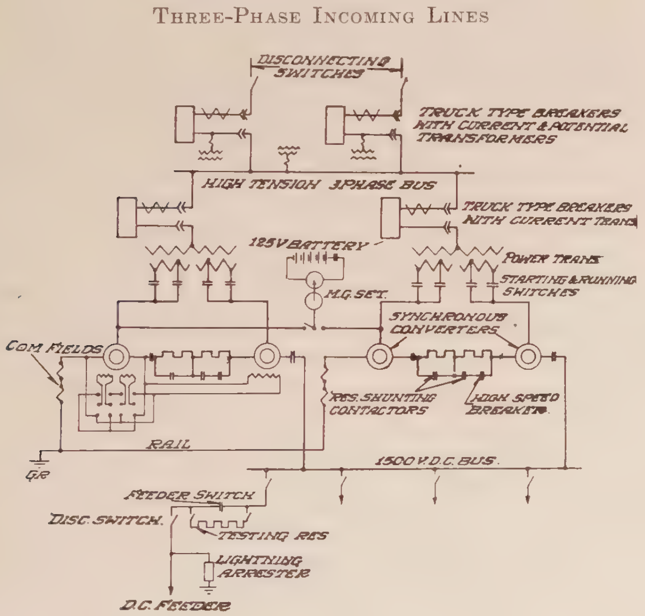


Fig. 1—Diagram of Connections for 1500-Volt D-C. Synchronous Converter Substation.

Fig. 1 is a schematic diagram of a substation equipped with two 1500-volt 50-cycle synchronous converter sets. Each set is made up of two 750-volt converters connected in series. Power is supplied from two high-tension lines through oil breakers. Selective protection is provided by induction-type reverse-power relays. Each transformer is constructed with double low-tension windings, one being for each converter of a set.

Each converter of the set shown in Fig. 2 is rated at 1000 kw., 50 cycles, 750 volts, d-c. In order to reduce the space requirements, both converters were mounted on a common bedplate with the center bearing pedestal common to the a-c. ends of both machines. The converters are not mounted on the same shaft. Each rotates in a clockwise direction as viewed from the commutator end. The converters are compound-wound and connected in series to deliver 1500 volts d-c.

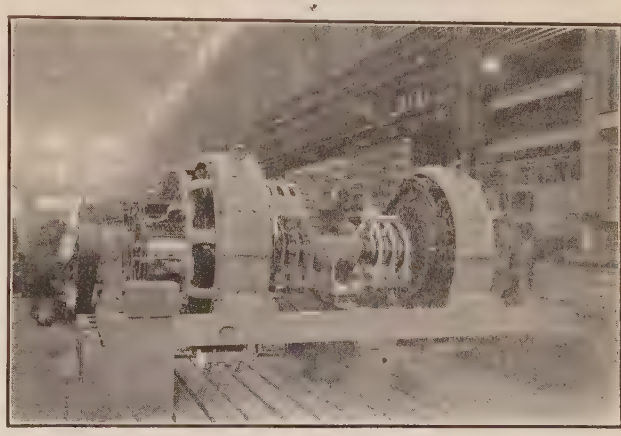


Fig. 2—2000-Kw. 50-Cycle 1500-Volt D-C. Synchronous Converter Set

The current-limiting resistor, one portion of which is shunted by a high-speed circuit breaker, is connected in series between the two converters. The shunt field of the converter connected to the trolley side of the system is permanently excited from the terminals of the machine, the negative side of which is connected to the rail return.

The lead-off set in the substation is started by means of a contact making voltage relay, the operating coil of which is connected permanently between trolley and rail. Both converters are a-c. self-starting through automatically controlled a-c. starting panels. The machine connected to the trolley side of the line is the first to start. When this converter has reached synchronous speed as is indicated by a drop in the starting current, an accelerating relay functions to start the machine connected to the negative or rail side of the system. Correct polarity is automatically established on the "low" machine, which, acting as an exciter for the "high" machine, establishes correct polarity on it also. The correct polarity thus automatically established on both machines, the transition from the a-c. starting voltage to full running voltage is made simultaneously on both machines.

After the closing of the a-c. running switches, the machines are controlled electrically as a single unit in exactly the same manner as the equipment in 600-volt railway substations, which are now so well known and so nearly standardized for this class of service.

The means for starting the second set are the same

as those supplied for multiple-unit stations operated at the lower voltages. The second set is started by the functioning of a relay, which, in effect, measures the temperature of the first machine. In case the first set is subjected to sudden overload, causing current-limiting resistance to be cut into the circuit or the voltage to drop to a predetermined limit for several seconds, the second set is started. The machines shut down on light load in the inverse order of starting.

The protective features such as bearing thermostats, overload relays, voltage protection, etc., are the same as those concerning which a great many articles have appeared in the trade journals.

Scheme of Control for the Operation of D-C. Feeder Circuits

The d-c. feeder equipment shown on the right hand of Fig. 3 is for supplying heavy suburban traffic and is known as the short-circuit detector type equipped with automatic reclosing features. This type of d-c. feeder

Fig. 3—Automatic Switchboard for Controlling a 4000-Kw. 1500-Volt D-C. Railway Substation Equipped with Two Sets Each, a Duplicate of the One Shown in Fig. 2. The Panels at the Right Control Eight 2000-Ampere D-C. Feeder Circuits

equipment differentiates between legitimate overload and short circuit, opening only to clear a short circuit. It has become a standard for automatic railway substations.

Any short-circuit impulse will, through separate and independent means, cause the high-speed breaker in the machine circuit and the breaker in the faulty feeder circuit to open. Due, however, to the characteristics of the two types of breakers, the high-speed breaker will open ahead of the feeder breaker and insert a block of load-limiting resistance. The value of this resistance is so adjusted as to limit the current on short circuit to the commutating capacity of the machine. As soon as the faulty feeder has been isolated by the opening of the feeder breaker, automatic reclosing devices function to re-establish full voltage by reclosing the quick-acting breaker to shunt the load-limiting resistor. The opening of the breaker in the faulty feeder circuit also sets up a testing bridge resistance circuit so arranged as to measure the resistance of the external circuit. When the trouble has been cleared and the resistance increased to approximately normal, a circuit is set up and the feeder switch automatically reclosed.

During any load incident to normal operation, such as the simultaneous acceleration of heavy trains, the feeder switch remains closed and supplies power at normal voltage, so long as the demand on the machine is not sufficient to cut in the current-limiting resistors through the operation of the overload relays. This type of feeder protection permits taking advantage of the short-time overload capacity of the d-c. feeder system under all normal operating conditions, even though the current may momentarily reach values in excess of those under some short-circuit conditions.

The circuit breakers on the feeder circuits are mechanically latched and are not dependent upon the d-c. bus voltage to hold them closed, therefore, they will remain closed regardless of the value of that voltage. Closing energy is taken from a storage battery. Due to the inherent characteristics of quick-acting circuit breakers, it is necessary, when used for feeder protection, that the holding coil circuits be energized from the substation bus, unless an excessively large control battery is provided for this purpose. If this breaker is to properly select between short circuit and legitimate overload, it must be set to open on voltage reductions which may occur in normal operation, due to the functioning of the load-limiting devices which are arranged to reduce the bus voltage to a value which will protect the station against continued overload by transferring the load to adjacent stations. It is very evident, therefore, that such breakers, if set for selective action between short circuit and overload, are very liable to open, due to drop in voltage, when it is most important that they should remain closed.

Inasmuch as the high-speed characteristic of the breaker is essentially for machine protection, the breaker should be connected in the machine circuit and operated from voltage supplied by the machine. Thus, while the breaker is closed, it is supplied with a source of constant potential which makes it possible to accurately adjust the tripping mechanism. This tripping value will be such as to protect but one unit and therefore the high-speed breaker protection applied independently to each machine will be constant and independent of the number of units in operation.

Automatic switching for the control of motor-generators supplying 1500-volt d-c. follows the same scheme as that used for stations supplying the lower railway voltages, except where two generators are connected in series, in which case the control of the d-c. end of the set is very similar to that for the two converters in series as has already been described.

Insulation Tests of Transformers as Influenced by Time and Frequency

BY FRED. J. VOGEL

Assoc. A. I. E. E.

Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Review of the Subject.—*Many transformers are now being designed for service with one end of the high-voltage winding solidly grounded. These transformers require an overpotential test by induced voltage of either 2.73 or 3.46 times their normal line voltage above ground plus 1000 volts. These tests must be made at more than normal frequency, to avoid too high a flux density in the core, and also to reduce the power required for excitation. It has long been known that the breakdown voltage of solid materials was affected by the length of time of application of voltage. Likewise the frequency of the applied voltage is shown to affect the breakdown voltage for solid insulations, increase in the frequency resulting in a decreased breakdown voltage. The voltage required for creepage failure is shown to be relatively unaffected by frequency. From the results of the tests made it is concluded that induced voltage tests on transformers with graded insulation at higher than normal frequencies should not have the test voltage reduced, but should have the duration of the test shortened to make the severity of the test comparable to the test at 60 cycles on normally insulated transformers.*

WITH the advent of transmission voltages in the magnitude of 220,000 volts, on grounded neutral three-phase systems, there has been an increased tendency to design the transformers with graded insulation, that is, with insulation to ground or between windings in proportion to the actual existing voltages between these parts. With this design, the 60-cycle high-potential test from the high-voltage windings to the other windings and core, based on twice the three-phase line voltage plus 1000 volts, becomes impossible and a substitute in the form of an overpotential test by induced voltage is required. An overpotential test for such transformers frequently used by the Westinghouse Electric & Manufacturing Co. is 2.73 times the normal voltage above ground plus 1000 volts. This test requires the use of a frequency at least 2.73 times the normal frequency of the transformer, to keep the core density down to normal values. Therefore, it is seen that the insulation must be tested at higher than the normal frequency (60 cycles) used in the older high-potential tests. It is the purpose of this paper to discuss the relation of insulation breakdown to the frequency of the impressed voltage as determined experimentally for some special cases.

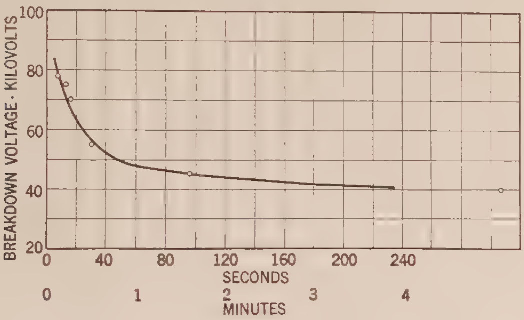


Fig. 1—Time-Voltage Puncture Curve at 60 Cycles
1/8-in. oil-impregnated fullerboard at 25 deg. cent.

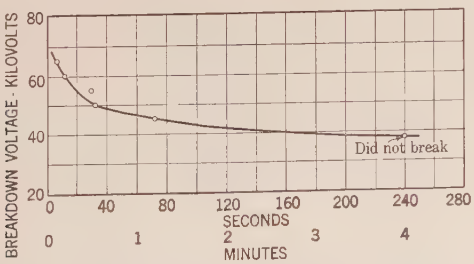


Fig. 2—Time-Voltage Puncture Curve at 140 Cycles
1/8-in. oil-impregnated fullerboard at 25 deg. cent.

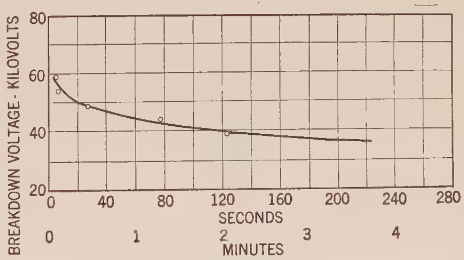


Fig. 3—Time-Voltage Puncture Curve at 220 Cycles
1/8-in. oil-impregnated fullerboard at 25 deg. cent.

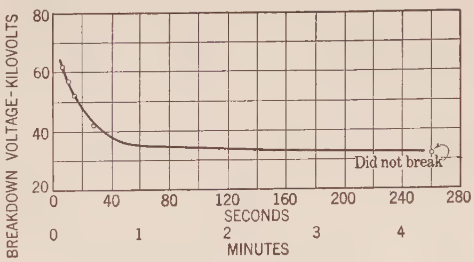


Fig. 4—Time-Voltage Puncture Curve at 350 Cycles
1/8-in. oil-impregnated fullerboard at 25 deg. cent.

Types of Insulation Failure and Methods of Testing

There are two possible divisions of failure under oil, one in which oil failure alone is considered, that is, where no solid material is punctured, and one in which there is puncture of solid material. These can still be

Presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., Feb. 4-8, 1924.

further sub-divided into oil jump or creepage over the surface of solid material and puncture of solid material alone or with oil ducts intervening between the sheets of solid material. The investigation, therefore, naturally divides itself into two parts, and the methods of testing used are divided in this manner.

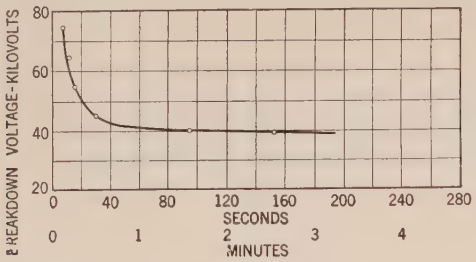


Fig. 5—Time-Voltage Puncture Curve at 60 Cycles
1/8-in. oil-impregnated fullerboard at 75 deg. cent.

Individual readings in the tests involving oil failure have a tendency to be erratic. In fact, this tendency is so pronounced that it was decided not to attempt to procure average values, but rather to determine the

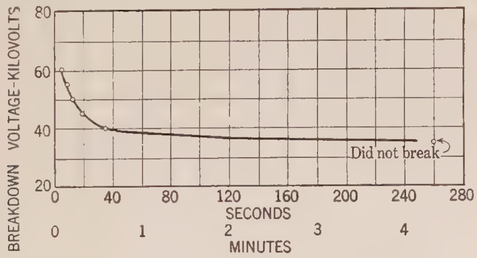


Fig. 6—Time-Voltage Puncture Curve at 140 Cycles
1/8-in. oil-impregnated fullerboard at 75 deg. cent.

maximum voltage which could be held a given length of time, for a considerable number of tests. To determine this, five minutes was selected as a unit of time, and tests made, starting at a fairly high value and

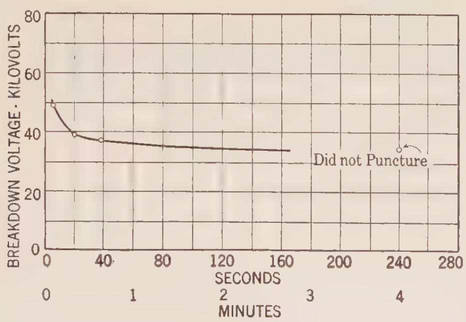


Fig. 7—Time-Voltage Puncture Curve at 220 Cycles
1/8-in. oil-impregnated fullerboard at 75 deg. cent.

decreasing the test voltage until the voltage was held four or five times for the desired length of time, in succession, with no breaks.

In making puncture tests where solid material was punctured, the effect of the duration of the test on the breakdown voltage was studied to determine the basis for comparison between the different frequencies. The following method was in general used to procure the individual time-breakdown voltage curves.

The field current leads of the generator supplying power were brought to the testing transformer regulating equipment, arranged so that the field current could be adjusted and the field circuit opened or closed. This permitted the most rapid application of voltage without surges by closing the generator field switch. The voltage corresponding to a given

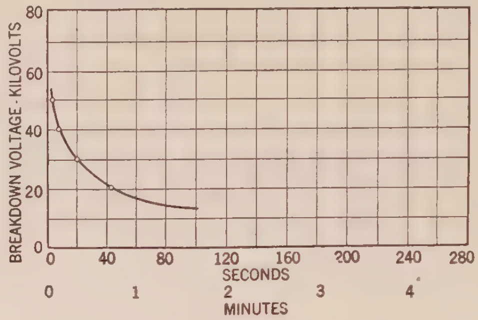


Fig. 8—Time-Voltage Puncture Curve at 350 Cycles
1/8-in. oil-impregnated fullerboard at 75 deg. cent.

setting of the regulator was then determined by spark gap. This setting was left undisturbed and the voltage then applied to the test piece by closing the generator field switch. Settings up to the continuous voltage strength of the test piece were checked with the spark gap and test piece in parallel, and the readings corrected to suit, as some variation occurred due to the charging current of the test piece. In the individual readings the time was noted at which failure occurred from the time the generator field switch was closed.

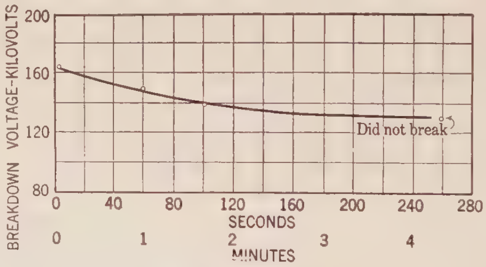


Fig. 9—Time-Voltage Puncture Curve at 60 Cycles and 25 deg. cent.
3 sheets oil-impregnated 1/8-in. fullerboard with alternate 1/8-in oil ducts. Tested horizontally

In order that an idea of the times required for application of the voltage may be had, oscillograms showing the relation between the voltage, as it built up, and time were taken. These indicate the following times for building up of voltage after the generator field switch was closed: 50,000 volts, 60 cycles, built up in 1 second; 40,000 volts, 140 cycles, built up in 1.22 seconds; and 50,000 volts, 220 cycles, built up in 0.5 seconds. The same machine was used for the

350-cycle tests as for the 220-cycle, and the time should be less for the 350 cycles than for the 220 cycles, since for the same voltage less field current is required. In the worst case, therefore, the data taken give the

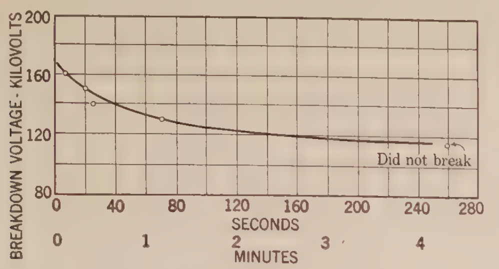


FIG. 10—TIME-VOLTAGE PUNCTURE CURVE AT 140 CYCLES AND 25 DEG. CENT.

3 sheets oil-impregnated, 1/8-in. fullerboard alternate 1/8-in. oil ducts. Tested horizontally.

times to within one or two seconds of time, except for certain tests on fullerboard at 60 cycles and in oil at 75 deg. cent. In these, nearly four seconds elapsed, but it was believed that it did not greatly affect the

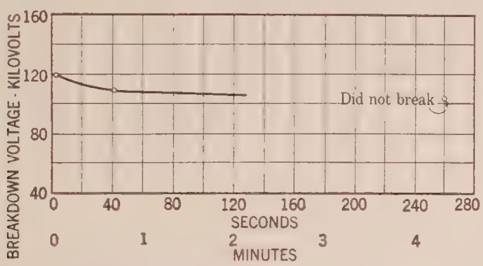


FIG. 11—TIME-VOLTAGE PUNCTURE CURVE AT 220 CYCLES AND 25 CENT. DEG.

3 sheets oil-impregnated, 1/8-in. fullerboard with alternate 1/8-in. oil ducts. Tested horizontally.

reading at one minute intervals of time, and hence these curves were not rechecked.

The wave form in each case was of pure sine form for the 60-cycle and 140-cycle frequencies. It was

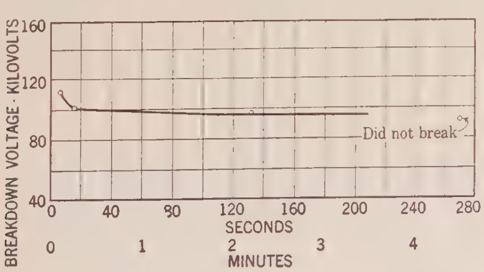


FIG. 12—TIME-VOLTAGE PUNCTURE CURVE AT 350 CYCLES AND 25 DEG. CENT.

3 sheets oil-impregnated 1/8-in. fullerboard with alternate 1/8-in. oil ducts. Tested horizontally.

impossible to make good oscillograms at 220 and 350 cycles, but the wave form is believed to be satisfactory. At all events, due to the method of test calibrating against spark gap, these data are based on crest values of the wave.

CREEPAGE TESTS

Creepage tests were made under oil, between electrodes on opposite sides of a barrier of four ⅛-in. oil-impregnated fullerboard sheets. The electrodes were located by gage ½ in. from the edge. The electrodes were of brass, 4 in. in diameter with ½ in. radius. The barriers were placed in a horizontal position.

The individual readings of the tests at 60 cycles varied so much that it was decided not to try to find average times for a given voltage setting, but rather

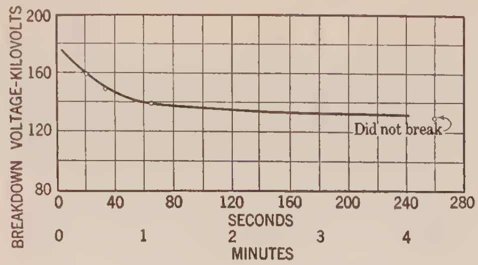


FIG. 13—TIME-VOLTAGE PUNCTURE CURVE AT 60 CYCLES AND 75 DEG. CENT.

3 sheets oil-impregnated 1/8-in. fullerboard with alternate 1/8-in. oil ducts. Tested horizontally.

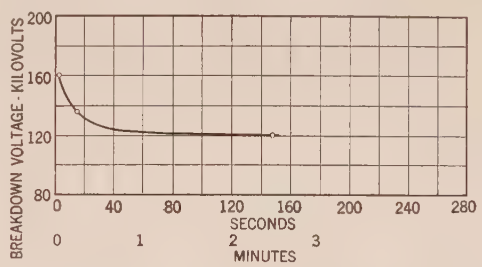


FIG. 14—TIME-VOLTAGE PUNCTURE CURVE AT 140 CYCLES AND 75 DEG. CENT.

3 sheets oil-impregnated 1/8-in. fullerboard with alternate 1/8-in. oil ducts. Tested horizontally.

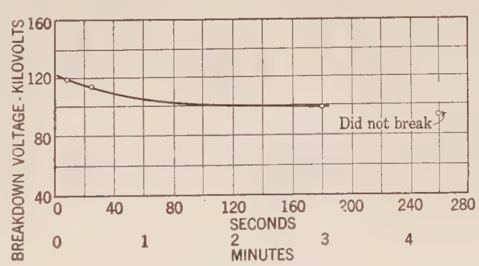


FIG. 15—TIME-VOLTAGE PUNCTURE CURVE AT 220 CYCLES AND 75 DEG. CENT.

3 sheets oil-impregnated 1/8-in. fullerboard with alternate 1/8-in. oil ducts. Tested horizontally.

to find the maximum voltage which could be held fairly continuously (5 minutes) for a number of trials with *no* failures. An idea of the variation of these readings is shown by the following data: Voltage setting, 75 kv.; oil temperature, 25 deg. cent.; time of application, 1 min., 56 secs.; 1 min. 8 secs.; 3 secs.; 4 ½ secs.; 4 min. 41 secs.; 2 min. 1 sec.; 7 min., 36 secs.; 8 secs. The above are the first eight of twenty-eight readings, of which the maximum was

13 min., 14 seconds, and the minimum, 3 seconds. Readings taken at 74 kv. were all of greater length of time than 15 minutes, no failures noted.

A table of the results obtained at other temperatures and frequencies follows:

TABULATION OF CREEPAGE DATA

Voltage held without break in five minutes.

4 in. diameter electrodes, ½ in. from edge of barrier composed of four ⅛ in. fullerboard sheets, placed horizontally.

Frequency	25 deg. Centigrade	75 deg. Centigrade
60 cycles	74 Kilovolts	78 Kilovolts
140 "	80 "	80 "
220 "	81 "	81 "
350 "	72 "	Punctured solid material

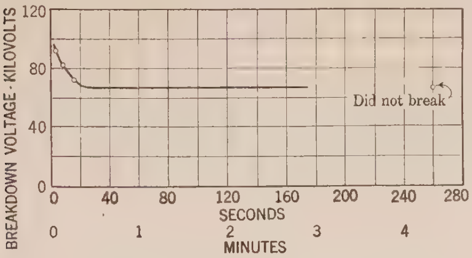


Fig. 16—Time-Voltage Puncture Curve at 350 Cycles and 75 deg. cent.

3 sheets oil-impregnated 1/8-in. fullerboard with 1/8-in. oil ducts. Tested horizontally.

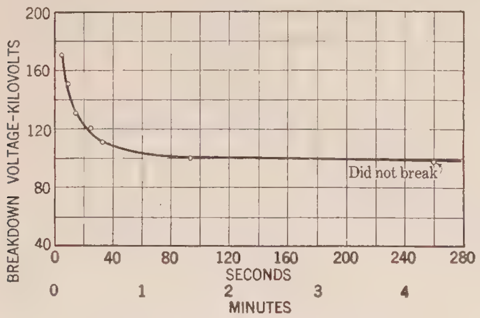


Fig. 17—Time-Voltage Puncture Curve at 60 Cycles and 25 deg. cent.

2 sheets 1/8-in. oil-impregnated fullerboard separated by 3/8-in. oil duct. Tested horizontally.

Variation of Breakdown Voltage of Barriers under Oil

A number of different conditions were investigated, at two temperatures, 25 deg. cent. and 75 deg. cent. These were, puncture voltage of ⅛-in. thick fullerboard, puncture voltage of three sheets of ⅛-in. fullerboard separated by ⅛-in. thick spacers, giving ⅝-in. puncture distance, and puncture voltage of two sheets of ⅛-in. thick fullerboard, separated by ⅜-in. thick spacers, giving ⅝-in. puncture distance also. The barriers were placed horizontally except for a special test which is reported later. All fullerboard was vacuum-dried and oil-impregnated.

The method of test has been described previously. These data will be reported in the same order as described above, and the typical curve shapes shown for the relation between time and breakdown voltage for any frequency. The electrodes used were four inch diameter brass disks, with one-half inch radius.

Curves of the original data for all the different tests are shown, in curves 1 to 24. It will be seen that the curves are of similar shape, but it is not believed that they are sufficiently so that a representative curve can be drawn.

From these data the relative times can be derived for a given voltage to cause failure at the different frequencies. A tabulation of these results, based on a voltage sufficient to cause failure at the end of one minute at 60 cycles, follows:

Tests on ⅛-in. fullerboard.
Fullerboard placed horizontally in tank.
Curves 1 to 8 inclusive.

Breakdown Voltage	60 cycles	140 cycles	220 cycles	350 cycles
	Times for breakdown at 25 deg. cent.			
48,000	1 min.	50 secs.	34 secs.	20 secs.
	Times for breakdown at 75 deg. cent.			
41,000	1 min.	30 secs.	16 secs.	7 secs.

Tests on Barriers
Three ⅛-in. thick fullerboard plus two ⅛-in.
Oil ducts, alternating fullerboard and oil.
Tested horizontally.*
Curves 9 to16, inclusive.

Breakdown Voltage	60 cycles	140 cycles	220 cycles	350 cycles
	Times for breakdown at 25 deg. cent.			
149	1 min.	20 secs.	Inst.	Inst.
	Times for breakdown at 75 deg. cent.			
141	1 min.	12 secs.	Inst.	Inst.

Tests on Barriers,
Two ⅛-in. fullerboard plus one ⅜ in.
Oil duct between fullerboard sheets. Tested horizontally, Curves 17 to 24.

Breakdown Voltage	60 cycles	140 cycles	220 cocles	350 cycles
	Times for breakdown, 25 deg. cent.			
102,000	1 min.	42 secs.	18 secs.	14 secs.
	Times for breakdown, 75 deg. cent.			
106,000	1 min.	50 secs.	14 secs.	Inst.

Application of Data to Tests on Apparatus

From the above data, testing apparatus at higher frequencies increases the severity of the test rapidly. The principal reason for the adoption of the trans-

*1. The tests at 25 deg. cent. at 60 cycles and 350 cycles, were also made with the barriers and oil ducts vertical. It was felt that some increase might result due to freer oil circulation, and it was indeed noted that the shapes of the curves were more nearly the same, and that they were higher than those where the barriers were horizontal. See curve 25 for comparison with curves 9 and 12. The horizontal tests were made as illustrating worst possible conditions.

former with graded insulation is to reduce the amount of insulation required, and if it is found necessary to increase parts of the insulation, merely to meet tests, over that required for the normally insulated transformer tested at the lower frequency of 60 cycles, its

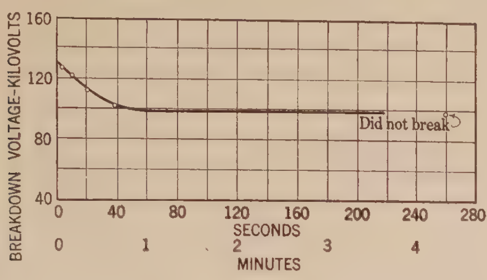


FIG. 18—TIME-VOLTAGE PUNCTURE CURVE AT 140 CYCLES AND 25 DEG. CENT.

2 sheets 1/8-in. oil-impregnated fullerboard separated by 3 8/in. oil duct. Tested horizontally.

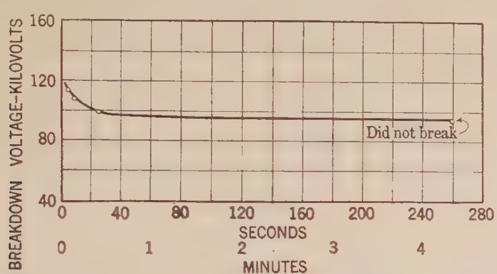


FIG. 19—TIME-VOLTAGE PUNCTURE CURVE AT 220 CYCLES AND 25 DEG. CENT.

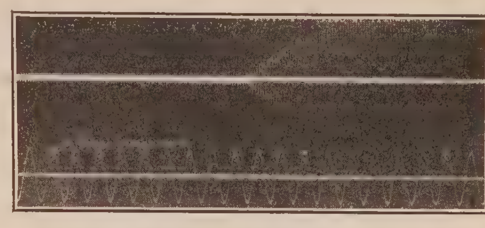
2 sheets 1/8-in. oil-impregnated fullerboard separated by 3/8-in. oil duct. Tested horizontally.

BUILDING UP OF FIELD ON 140-CYCLE GENERATOR TRANSFORMER REGULATOR SET FOR 40-KV.

BUILDING UP OF FIELD ON 60-CYCLE GENERATOR FIELD EXCITED BY 500 VOLTS INSTEAD OF 110 VOLTS

advantage is to some extent at least lost. For this reason the designer is interested to determine what insulation test, if any, would test such apparatus to the same severity as if it could be tested at 60 cycles.

Referring to the results of the creepage data, it would appear that failures due to creepage are not greatly affected by frequency. This is more or less to be expected, for the following reasons: Creepage breakdown, in the absence of foreign conducting material, is probably largely a question of oil failure. For fluids it would also be expected that frequency would not result in quite as large a decrease in the breakdown voltage as for solid material, due to the relative absence of the effect of heat. For air, indeed, the effect of frequency is very slight. Therefore no decrease in the actual voltage



BUILDING UP OF FIELD ON 220-CYCLE GENERATOR SUPPLYING 300-KV. TRANSFORMERS.

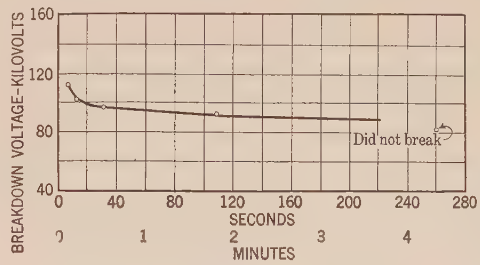


FIG. 20—TIME-VOLTAGE PUNCTURE CURVE AT 350 CYCLES AND 25 DEG. CENT.

2 sheets 1/8-in. oil-impregnated fullerboard separated by 3/8-in. oil duct. Tested horizontally.

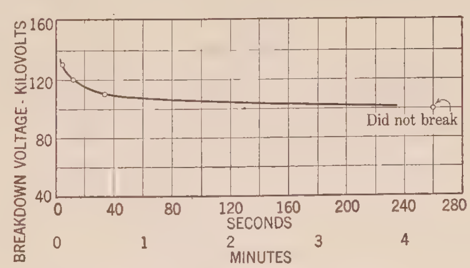


FIG. 21—TIME-VOLTAGE PUNCTURE CURVE AT 60 CYCLES AND 75 DEG. CENT.

2 sheets 1/8-in. oil-impregnated fullerboard separated by 3/8-in. oil duct. Tested horizontally.

applied for test would be desirable. On the other hand, the effect of time is not as great for this type of breakdown. Down to the point at which the applied voltage could be held permanently, the tests were erratic, but the point at which it would hold this voltage appeared to be quite definite. Very slightly above the critical voltage tests of relatively very short time might be obtained. It would be recommended, therefore, that for any test at over 60 cycles contemplated to equal the severity of a 60-cycle, one minute test, that no decrease

in the testing voltage be made, but rather that the duration be decreased to provide for decreased puncture strength of the solid material.

At some places in a transformer insulation failure would involve the puncturing of fullerboard entirely, at others only a portion of fullerboard and oil in series. Observation of the puncture curves would indicate that variations occur with the different percentages of fullerboard which are impossible to reconcile into any kind of

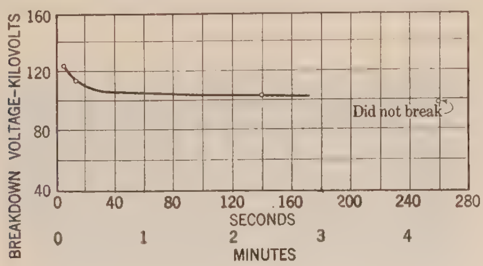


Fig. 22—Time-Voltage Puncture Curve at 140 Cycles and 75 deg. cent.

2 sheets 1/8-in. oil-impregnated fullerboard separated by 3/8-in. oil duct. Tested horizontally.

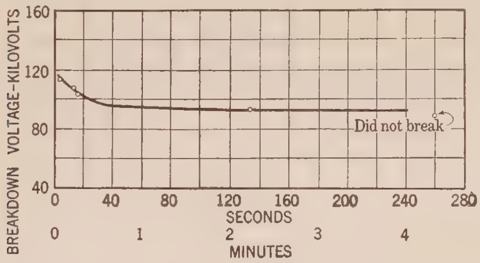


Fig. 23—Time-Voltage Puncture Curve at 220 Cycles and 75 deg. cent.

2 sheets 1/8-in. oil-impregnated fullerboard separated by 3/8-in. oil duct. Tested horizontally.

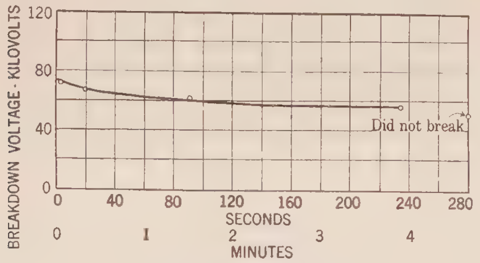


Fig. 24—Time-Voltage Puncture Curve at 350 Cycles and 75 deg. cent.

2 sheets 1/8-in. oil-impregnated fullerboard, separated by 3/8-in. oil duct. Tested horizontally.

average or representative data. Possible reasons for these variations are as follows: For the ⅛-in. fullerboard it is possible that the electrodes, of brass, reduced the heating of the fullerboard due to its large thermal capacity. This possibly would increase the duration of time for a given breakdown voltage and make it longer in the case of the higher frequencies than for the other combinations as tabulated above. For the barriers with the three sheets of fullerboard it is apparent that the higher frequency tests are very severe. For the barriers with two sheets, the conditions are less severe. This might be expected, since if oil is the less affected by frequency, the less the percentage of fullerboard in a given distance, the less the breakdown voltage should be affected by frequency.

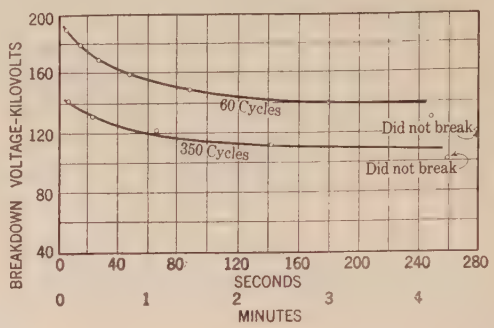


Fig. 25—Time-Voltage Curve at 60 and 350 Cycles 25 deg. cent.

3 sheets 1/8-in. oil-impregnated fullerboard with alternate 1/8-in. oil ducts. Tested vertically..

In an actual transformer, for the higher voltages, a large proportion of its insulation between windings is of less than fifty per cent fullerboard. It is believed that forty per cent is a fair average of the minimum amount between the windings. From the point of view of making the test on the part least affected by frequency sufficiently severe, it would seem that the condition represented by the two sheets of fullerboard should be chosen. Accordingly it would be logical that the test voltage should be its normal value and that its duration should be decreased in line with the results of the tests, using the lower percentage of fullerboard.

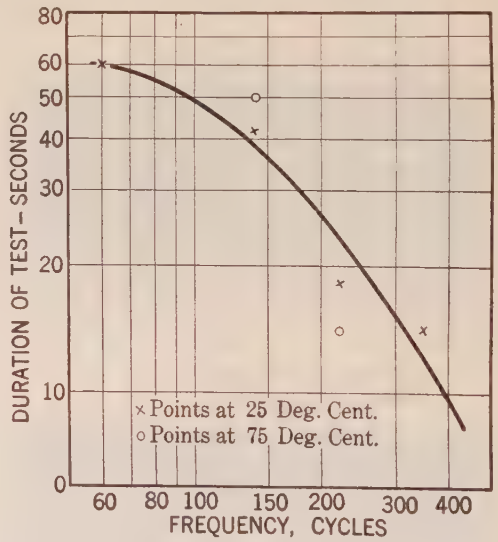


Fig. 26—Times for Puncture Tests at Different Frequencies Based on Voltage Giving Puncture in 60 secs. at 60 Cycles

X Points at 25 deg. cent.
⊙ Points at 75 deg. cent.

Fig. 26 shows points plotted between frequency and time, based on the voltage for puncture in one minute at 60 cycles, for both 25 deg. cent. and 75 deg. cent. These points, being values read from other curves whose individual accuracy may not be over 5 per cent, do not permit drawing a very accurate curve. The curve shown is fairly representative of conditions at both 25 deg. and 75 deg. cent., it is believed. It is perhaps slightly favorable to the apparatus at frequencies up to 150 or 160 cycles, but is decidedly unfavorable at frequencies much over 200 cycles, since apparatus is tested while hot, and the data show the higher frequencies, at 75 deg. cent. to be very severe.

From Fig. 26 the table which follows might then be proposed, for the application of induced test voltages, at higher than 60 cycles. The times are given for 164 and 208 cycles, since these are frequencies which are approximate multiples of test voltages required by the Standardization Rules of the American Institute of Electrical Engineers. The times given for the higher frequencies would require that extra insulation be given to the transformer above that needed if it could be tested at 60 cycles, but this is done to provide for the larger units, which may require testing at these frequencies to reduce the power required for testing.

Duration of Equivalent Induced Voltage Tests at Various Frequencies

Frequency	Time of Application
60 cycles	60 seconds
120 cycles	44 seconds
164 cycles (2.73 x 60)	33 seconds
208 cycles (3.46 x 60)	26 seconds
240 cycles	21 seconds
360 cycles	11 seconds
400 cycles	10 seconds

AN OLD EDISON D-C. GENERATOR

Through the courtesy of W. V. Boyd, Manager of Canadian Cottons Limited, Cornwall, Ontario, the Apparatus Sales Department has recently obtained from that Company an old Edison direct current generator, which they, when known as the Canada Cotton Company, purchased in 1882 from the Edison Machine Works of New York. The generator was installed during the early part of 1883 and was started in commercial operation on February 28th of that year. It was belted to a counter-shaft driven by a steam engine and was in actual use up to the year 1913, so that it was in service for 30 years, with one serious burnout of the armature which occurred during the Cornwall flood about 35 years ago, at which time the plant was completely covered with water.

We are led to believe that this was the second Edison generator installed in Canada. The first one, we understand, was installed in Vancouver, B. C. It is interesting to note, (as confirmed by letter from Thomas A. Edison's office) that Mr. Edison personally superintended the starting and the putting of the Cornwall plant into commercial operation and that this was the only Canadian installation thus superintended by him.

The Canada Cotton Company had built and equipped a new weave shed and wired it for electric lighting. The units were to be of the Edison carbon filament 16 candle power lamps, consuming about five watts per candle. The generator known as the type *L* had a rated capacity of 150 such lamps, and required 19 horse power to drive it at full load. The speed was 850 revolutions per minute, and driving pulley 14 in. diameter by 9 in. face. The overall dimensions are, height 78 in. and floor space 60 in. by 39 in.

The generator is of the multiple field magnet type, having two long field magnets per pole instead of the single short magnet per pole which existed in the final development of the Edison generator. Its weight is 4875 lb., as compared with 1465 lb., the weight of a modern d-c. generator of about the same capacity and speed, and 590 lb., the weight of a modern high speed machine of about the same capacity.

The following rather interesting and amusing editorial appeared in one of the local newspapers two days after the plant was started:

"The new weave shed of the Canada Cotton Co., was on Wednesday evening," Feb. 28th, lighted for the first time by the Edison Electric Light. It revealed, so we are informed, the objection which has in many instances been fatal to its success, and that is a too intense and flickering brilliancy. It has been established that the electric light when used in manufacturing establishments has produced all the most dangerous and afflicting forms of ophthalmia among the operatives. It may be that the light in the weave shed here possesses some exceptional charm—some soothing influence—for instance a liberal commission. However, if it ultimately proves a success we shall be pleased to chronicle the fact, but in the meantime, we agree with a leading English authority that electric light has had its day, and the fact that gas stocks are in no way affected by that light indicates that it is not regarded as a formidable rival."

It is not out of place to note here that Mr. Edison was one of the foremost, if not the foremost, of several American inventors who had the business acumen to see the commercial possibilities latent in Faraday's discovery in 1831, *viz.*, that electric currents were induced in conductors by moving them across the poles of a magnet, and he commenced experimenting in 1878, and in 1880 produced the first type of commercial Edison dynamo at Menlo Park, N. J.

The first commercial machine had a capacity of about 5 kw. and would operate 60-110 volt, 16 candle power lamps. Hundreds of these machines were built in the early eighties, many of them being shipped to Europe, twelve of them being sent to the Electrical Exposition at the Crystal Palace, Sydenham, London, England.

This old generator has been cleaned up and painted by us, and has been placed on exhibition in the entrance hall of the Ward Street Works Division.

Application of Automatic Substations to Central Station Service in Metropolitan Districts

BY C. W. PLACE
Member, A. I. E. E.
General Electric Co., Chicago, Ill.

Review of the Subject.—*The present trend to interconnection and the installation of large capacity stations, with the changing character of city load, make relief of the operating crew of a system of the greatest importance. This can best be done by the use of automatically controlled substations in the various types of service. Equipment for each class of service is in successful operation showing great dependability and any particular problem of the operating companies can be attached, keeping in mind certain fundamentals of design, construction and application.*

* * * * *

THE increase in use of electric power in the last few years and the very common interconnection between systems have greatly changed the situation in metropolitan districts with regard to power supply. The increase in power consumption has led to complications in design and has introduced a great many problems which were not present a few years ago. The industry has followed in its development work the necessity of greater use of power in a given district and the availability of equipment has in turn made possible the going to still greater density of power consumption. The natural effect of this growth has been that individual pieces of equipment have become exceedingly large, their importance in the system proportionately greater, and incidentally the first cost of each has increased.

As a side issue to this increase has come the difficulty of operators to grasp their entire situation, especially during times of stress and trouble. This has led to a load dispatcher system for each of the districts. The load dispatcher has nothing to do with the actual physical operation of the circuits, but merely directs the operation. The added complexity of the systems has made it necessary for him to have every facility, both to know what is going on and to be able to issue instructions promptly. Most of the larger cities and the surroundings have about reached the point where the human limitation will interfere unduly with continuity of service. Practically all systems are taking advantage of the higher-capacity, highly efficient, present-day generators; are installing very large generating stations to get the advantage of this higher efficiency; are going to high steam pressures, and using duplicate or ring busses in the station, bringing in more sources of energy, using heavy switching equipment, and doing all these things to increase the available power with safety and to insure the continuity of the service in a given district.

Practically every large city is throwing a loop around the city, connecting more sources of supply to this loop and feeding the load from it at advantageous points. This follows the ring bus in individual stations.

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All of this means that the operating crew must be given advantages to offset the greater complexity and responsibility thrown on them by these facilities and precautions in the equipment line. The most effective way to ease up on the operating force is to make as many of the operations follow conditions rather than instructions from the load dispatcher, aiming at all times at continuity of service to the consumer.

The application of parts and principles used in automatic control to the various types of operation necessary has been successfully made and a consequent improvement in overall service and relieving of the operating crew during times of trouble obtained. This application has and will allow greater density of load economically as conditions demand, and a review of these conditions and the way the conditions are met may be of decided advantage.

In practically all of the metropolitan districts the load has been growing around centers of commercial activity with intervening spaces of about the previous normal load density. If you will think over the large cities, you will recognize this situation as common, and also that these localized heavy load centers are not always at the most convenient point with regard to power supply. For instance, practically all cities have had a time of growth of apartment hotels or large apartment buildings in certain districts. This has caused regions of high load density with perfectly defined peaks, whose area is usually quite localized and does not change the load density in a closely adjoining territory. This region is usually well away from the generating station and points where heavy manufacturing load have been previously supplied.

It is such a growth or similar growth that makes the application of automatic control for the substations to supply the load most advantageous.

This type of growth resulted in the installations of quite a number of large and important automatic switching stations which have proven very successful in their operation.

Another type of growth that is taken off of this loop surrounding the city is the picking up of suburban towns from laterals running from this loop where small automatic switching stations give better service to these

towns and less overhead than would be occasioned by any other type of service.

The downtown districts of practically all of our larger cities are furnished with electrical service by direct current laid out on the Edison 3-wire system. These various cities were licensed to use this system of distribution in the early days as electrical experience goes, and have expanded around this system as a nucleus. At first the system was rather light weight, covering a comparatively large territory and was supplied to a great extent by belt-driven Edison Bipolar machines. As the city grew and certain sections acquired taller buildings, larger engine-driven units were installed in nearby steam stations and the copper underground increased to carry this load to the consumers. During this period, the cost of service and the relative degrees of experience by building managers and system managers, led to a great many of the larger buildings being put up to install isolated service, and run the generating system for each building, or small groups of buildings under common management. By the time skyscrapers became common the steam turbine came into common use, and as a consequence, the main power supply of cities became a-c. and converting equipment furnished for transforming this a-c. to d-c. for the Edison system.

As this process went on, the isolated plants were absorbed by the central station companies, and power supplied from the Edison system. Thus the magnitude of the present Edison System was a matter of gradual growth in all cases, and at no time has it appeared expedient to do away with d-c. in the downtown districts. The operating companies have had their capital investments in duct lines and heavy underground copper which would not be entirely suitable without expensive changes for a-c. operation. Customers have d-c. equipments in their buildings and sentiment indicated that the application of a-c. to elevator motors would not meet the conditions.

With the increase in the density of the load in the downtown districts, a reserve which could be called upon instantly in case of trouble or supply interruption could be obtained by installing storage batteries in the immediate vicinity of the load. All of the large cities have such storage battery reserves and have a large amount of money tied up in this part of their capital account. These storage batteries seemed necessary on account of the importance of the load from both the risk and revenue standpoint. All of these conditions have led the various utility companies to treat their downtown load entirely different from their residential load. They made it more steady and gave much more careful attention to this service than to an equal kilowatt capacity or load in the residential or manufacturing section. In most cases they get practically no better revenue per kilowatt-hour from the downtown load than from the residential load. It has as bad, or a worse, and also an uncertain load factor, and from all appearances the investment per kilowatt-hour of load is higher and the overall efficiency lower.

It would seem as if the d-c. load of the city is always held in greater respect than any other section of a central station company's business. This service is considered as almost sacred by the operators, whether from awe, admiration or fear is not exactly plain. From the troubles that occur when the district is shut down I believe this feeling is due to fear, and the feeling is similar to "devil-worship" among certain tribes. This has caused most of the central station companies to curtail the d-c. district, lopping off all of the edges of the district possible, thus confining the d-c. district to its original or a restricted territory.

When the nature of the load is considered, one can hardly see how this business can be carried on if the tendency for substituting twenty-story buildings for three-story buildings continues in the d-c. area. When a cloud over the sky can change the load of a d-c. district by tens of thousands of kilowatts, it is evident that this load is rightfully one which requires most careful consideration. The companies have installed large rotary-converter or motor-generator sets as close to the centers of the main system as possible. Large rotaries are installed under sidewalks and in basements three stories down. In times of trouble on the Edison System the whole tension of the Company's organization is given to keeping the machines going so that the batteries will not become exhausted and the system voltage lost. The result has been a duplication of supply and equalizer cables between substations, enormously heavy connections in the streets, as well as an attempt to keep sufficient capacity in converting apparatus. However, once in a great while the d-c. voltage is lost, due to a series of accidents and the problem of picking up the system without burning up important sections of cable or breaking up the system is enormous. Various methods have been devised in different parts of the country at considerable expense. Certain systems have control from a certain point which will allow the equivalent of all the feeder circuits being thrown on machines in motion and in operating condition at the same instant. Other systems have schedules arranged and duties assigned to various employees of opening and reclosing feeder circuits in certain sequence, transferring from bus to bus as the schedule demands. Other systems have considered splitting up the mains in the streets so that trouble would only involve one small portion and not communicate to surrounding zones. This would mean expensive construction in manholes, basements or space adjoining intersections.

The application of automatic stations to such service has relieved the extreme anxiety of the operation of such a system, especially in attempting to pick it up after an interruption. It has also led to a decrease in the chances of interruption, in that protective features have been furnished so that machines would not feed

out into the system more than their safe carrying capacity. This protection has allowed the substation equipment to stay with the system, both during time of extreme load from the system and shakeup in the a-c. supply. It has also allowed the substations to be located where they will be of greatest advantage, where the feeder losses can be kept down to a minimum and in locations where manual operation of stations would be difficult, if not impossible.

The application has shown very marked saving in previous losses absorbed by the central station company; has changed these losses into revenue load and has made it safe to put the Edison systems on the same basis as the a-c. section of the Company's business as regarding continuity of service.

This knowledge that the Edison System will be maintained just as long as there is a-c. supply and after an interruption will be restored as soon as this supply is available and not burn up cables or machines in the process, avoids the necessity of taking all the former precautions to prevent the Edison system being lost, in other words, the taking of sufficient precautions, but of a different and more economical form.

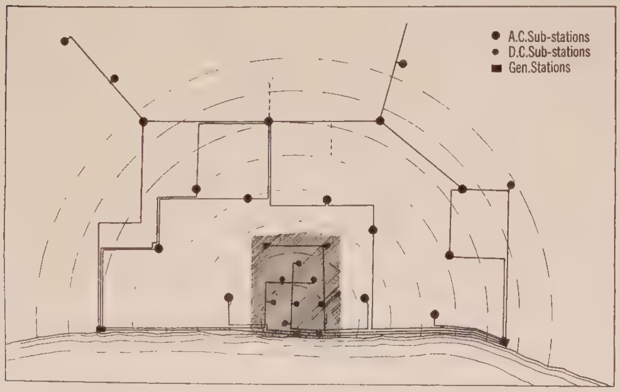

Fig. 1

Another application of automatic control which has proven of particular advantage is in the taking over of load previously carried by the Edison System on a-c. doing a wholesale business in power to large users in buildings in the old d-c. district. This makes it possible to continue serving a district by the original or equivalent d-c. equipment which, if fully a d-c. section, would be very heavy, but now interspersed with an a-c. system on the basis of wholesale a-c. power.

Now let us see what has been used to do these various things.

Fig. 1 shows what can be considered a one-line diagram of a high-tension distribution in a typical metropolitan district.

The water front is either the river or lake on which the city is located. The shaded portion is the d-c. district extending back from this water front with the heavy load about one-third back from the water.

You can make your own modification by putting in a little more or taking out some of the radial feeds.

On the outer fringe you will note the small a-c. stations. These are like Figs. 2, 3, 4, 5 and 6. Just inside the loop are the larger a-c. stations. These take the building form of Figs. 7 or 8, and the control equipment of Figs. 9, 10, 11 and 12.

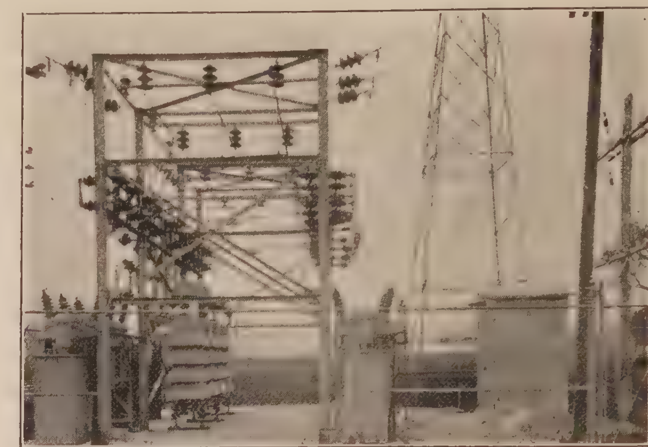

Fig. 2—Outdoor Incoming Line Equipment and Automatic A-C. Reclosing Feeder Station

Fig. 3—Outdoor Automatic A-C. Reclosing Feeder Station of the West Branch Light and Power Co., Stamford, N. Y., Prattsville Substation

The method of increasing the capacity of a station during the peak, decreasing it during the light load and supplying the substation, varies in different localities. Certain cities increase capacity by turning on water in combination self and water-cooled transformers.

Some throw on additional transformers to the main bus and others throw on transformers and segregate the bus in sections to keep loads of a certain magnitude radial for the supply.

These various methods of handling the a-c. loads are in successful operation and these and similar ways of going at the substation problem can be used to solve any of the distribution problems to meet the particular requirements of the operating company. The main precaution to be taken is that too many operations

Fig. 4—West Branch Light and Power Co., Stamford. N. Y. Prattsville Substation

Interior view of outdoor switch house showing automatic a-c. reclosing feeder, 6600-volt 3-phase 60-cycle (Front view).

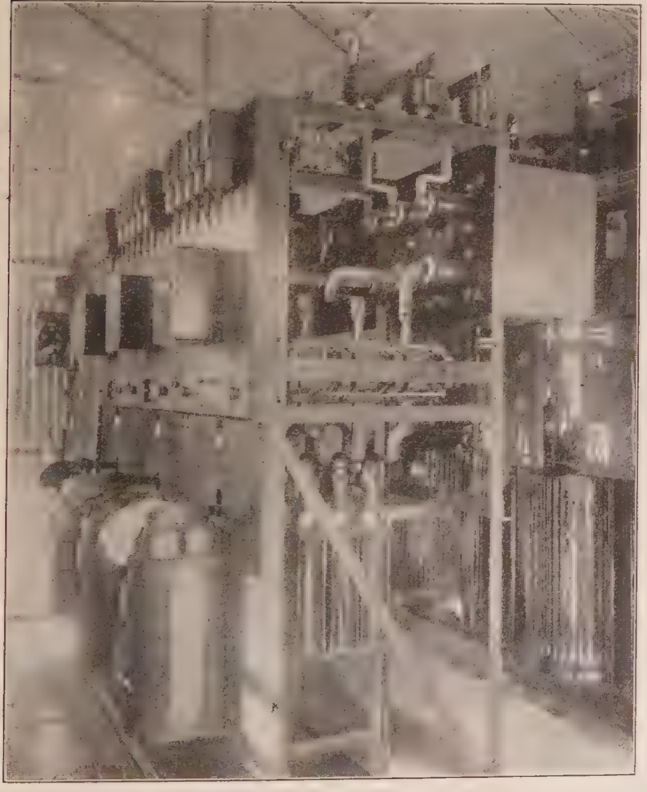

Fig. 5—Upper Hudson Electric and Railroad Co., Tannersville, N. Y.

Interior view of station showing automatic switching equipment for three a-c. reclosing feeders, each 4000 volts, 3-phase, 60-cycles.

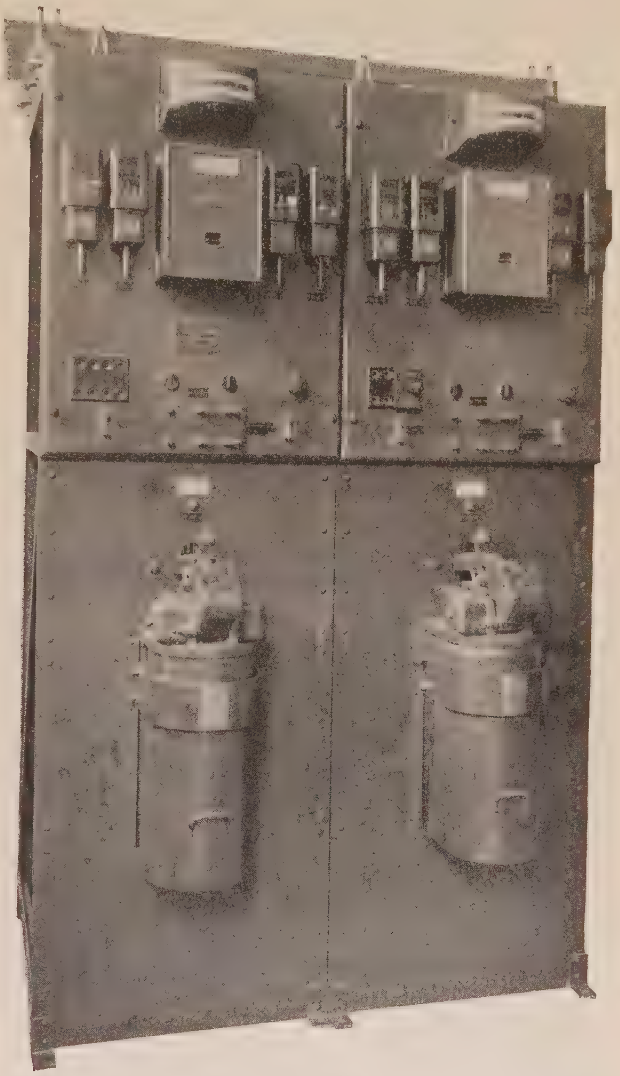

Fig. 6—Automatic Switching Equiment Edison Electric Company, Lancaster, Pa.

Two 4600-volt a-c. feeders 300-amperes 3-phase, 60-cycles. (Front view)

Fig. 7—Automatic Station Control Equipment, Kansas City Power and Light Co., Kansas City, Mo.

Automatic substation R, 6000-kv-a. 13,000/4150 2400 volts 60-cycles. (Exterior view).

should not be undertaken in providing against conditions which may not happen, or only happen occasionally. Fundamentally, the station should have its control so arranged that it will pick up the service from any available source and provide a sufficient station capacity to carry the load at the time. However, the station should not be allowed to become over-complicated by too much reserve switching arrangements. While it is possible to lay out, build and properly install almost any combination of switching which can be logically defined, the complication should be avoided for the benefit of the man who must maintain the station and find troubles. These may occur, due to maintenance conditions or to operations performed manually in order to get a chance to work on particular circuits or transformers. In other words, the effort should be made not to transfer the operating difficulties, due to complexity and magnitude of the system, from the operating crew to the maintenance crew.

FIG. 8

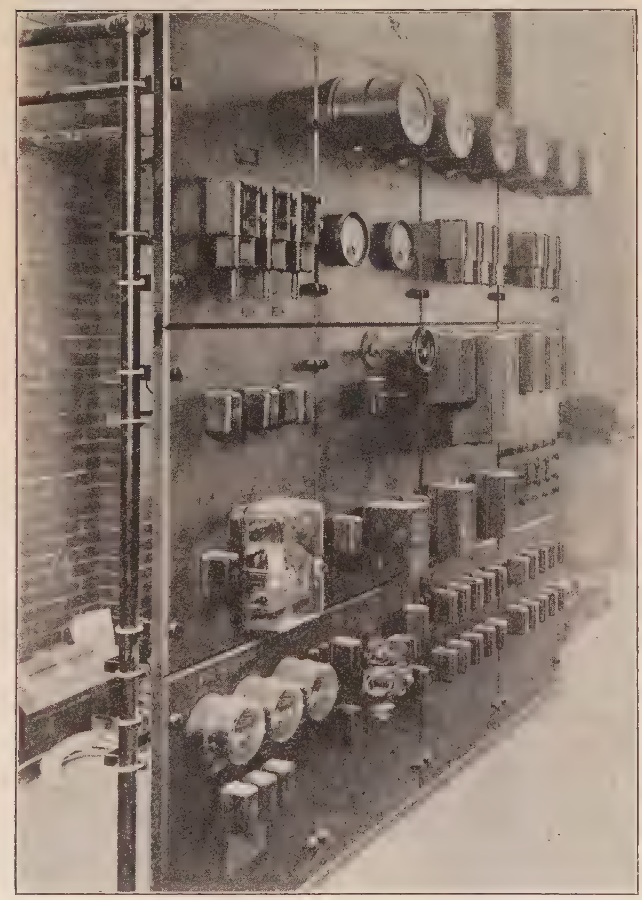

FIG. 9—AUTOMATIC STATION CONTROL EQUIPMENT STATION R, KANSAS CITY POWER AND LIGHT CO., KANSAS CITY, MO. FRONT VIEW OF MAIN RELAY PANELS AND MASTER SWITCHES

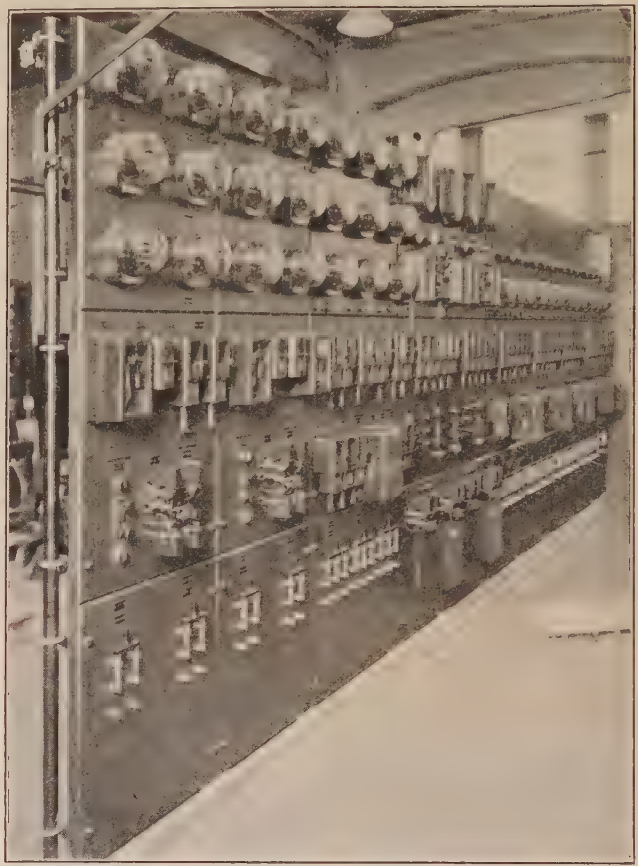

FIG. 10—AUTOMATIC SWITCHING EQUIPMENT, MILWAUKEE ELECTRIC RWY. AND LIGHT CO., MILWAUKEE, WISC., NORTH MILWAUKEE STATION

For incoming lines 26,400 volts and 13,200 volts and a-c. reclosing feeders, 4000 and 2300 volts (Front view).

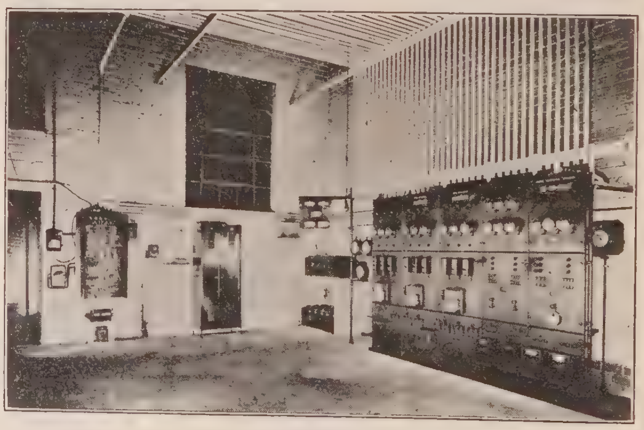

FIG. 11

With automatic control of such stations the control equipment can be located at points close to the parts to be controlled and thus the size of building can be cut down, conduit and secondary wiring shortened and instruments required for hand control of such a station omitted. All this leads to economy in installation, which, to a certain extent, compensates for the added cost of the automatic control features. It usually works out that, overhead and operating expense being considered, the automatic station can be justified by the smaller annual charge. However, this saving is not the main factor, but rather the item of continuity of service and the establishing of sections of the city which will take care of themselves without direction from the load dispatcher, just as long as he can give them a-c. supply.

The obtaining of a location for an a-c. automatic station in a residential district is not difficult. The stations are easily made of an attractive appearance and are a credit to any neighborhood. They are not noisy and after they are completed there are no objectionable features.

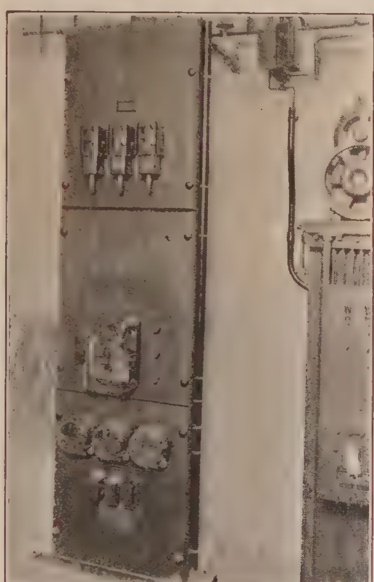

Fig. 12—Automatic Station Control Equipment Station R, Kansas City Power and Light Co., Kansas City, Mo. Front View of Typical Group Relay Panel

In the d-c. Edison 3-wire district, the application of automatic control has taken one of four forms:

1. The equipping of booster-type rotaries already installed for automatic control.

2. The equipping of motor-generator sets, either for control by external load limit or by modifying the set to approximate the heavy duty differentially-wound motor-generator set.

3. The installation of new motor-generator sets differentially-wound.

4. The installation of shunt rotaries with external load-limiting features.

All of these are in successful commercial operation, so it is possible at the present time to attack any substation problem, knowing that it has been done before in practically the form which may be demanded. The stations which are in operation are performing very creditably. They have proven that they can pick up the Edison load after an outage in a very definite time after the a-c. source has been restored. They have also proven that they will stay with the system during severe a-c. disturbance. If one station happens to get shaken off, due to its being electrically near the center of the disturbance, it will come back into the load as soon as a starting voltage is supplied. In the meantime, stations that remain with the load will not suffer, due to the absence of the one shaken off, but will adjust themselves to give out the limit of their current capacity and allow the voltage to slip to keep the load within the current capacity. We can thus with assurance attack the automatic operation of existing machines.

The principles, which should guide the operation company in selecting additions to their substation equipment for the Edison system or replacement of older or less efficient equipment, are as follows:

A motor-generator set with current-limit ability should be selected where the addition is to be made at a location where the machine will have to operate only during the peak or after a disturbance where the slightly poorer efficiency will not be the important factor, or where power-factor correction is important. These machines will not shake off of the system during any disturbance and will immediately restart on the restoration of supply.

A shunt-wound rotary should be installed where it is to operate over long periods, where it is close to the load so that the voltage regulation range will be within the regulating ability of the machine, and where the overall efficiency is of importance.

From my viewpoint the motor-generator set should be installed where it is to be added to existing stations, or in a particular location where there is a periodic load of short duration, where the load at other times of the day can be economically maintained from the existing network.

The shunt-wound rotary should be installed where it will get a good heavy load during all but the off-peak period, or where it replaced antiquated or undersized equipment in the midst of a heavy load.

The 60-cycle shunt-wound rotary has proven very stable for such service and in maintaining a flat manhole voltage, picking up the load after failure of a-c. supply through its current-limiting equipment and operating on a commercial a-c. power supply.

The main precaution to be taken in such stations is that sufficient ventilating capacity be provided. With motor-generator stations, the natural thing, on account of the smaller physical dimensions of the set, and the fact that a man does not have to be present during its

operations, is to put it in a small space. The greater losses naturally require greater ventilation and difficulty is usually encountered in providing it.

When adding a shunt-wound rotary to the system, the precautions to be taken include the supplying of clean air for ventilation, but in smaller quantities than for motor-generator set stations.

In applying automatic control to stations supplying

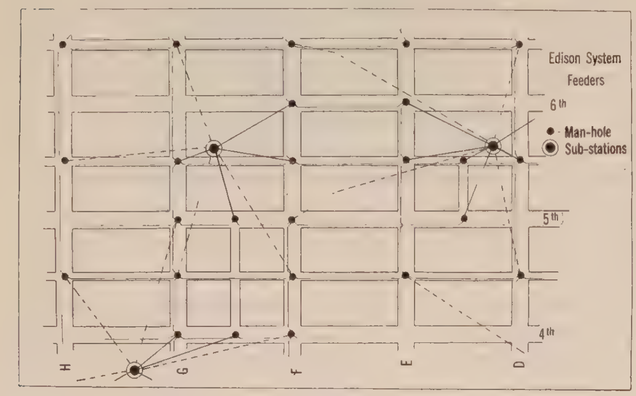

Fig. 13

an Edison System, it should be remembered that where machines come on, due to a droop in voltage, and go off on loss or decrease of load to a certain point, the regulation of the d-c. system should be such that the manhole voltage which brings on the added machines can decrease enough to cause the machines to come on. After they are on, the regulation attempted should be coarse enough to allow the machines to stay on and

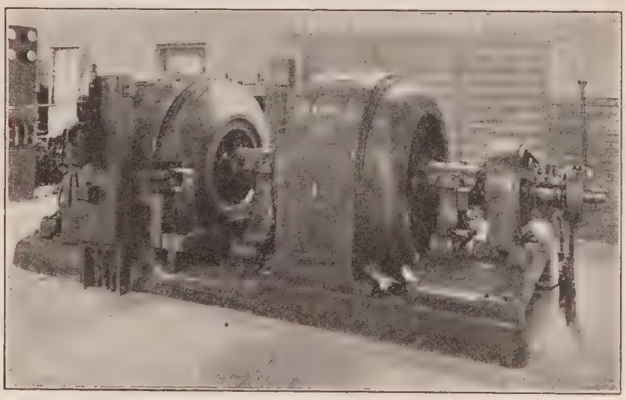

Fig. 14—New Orleans Public Service Co., New Orleans, La., Bourbon St. Station

Interior view showing automatically controlled synchronous motor-generator set. Motor 900 rev. per min. 6600 volts, 60-cycles. Generator 130/260 volts.

carry load. In other words, the feeders to the Edison System from automatic stations should be interleaved as between stations and the buses in the streets should not be so heavy as to avoid voltage drop which will bring on the necessary machine capacity.

Fig. 13 will illustrate what is meant by the interleaving of feeder cables.

No doubt difficulty will be experienced in practically every city in locating automatic stations in the Edison district. The selection of locations is assisted by remembering that the noise of the machines is of a nature which does not reach other parts of the building, except through the air intake and outlet; also by remembering that these can be baffled to avoid this

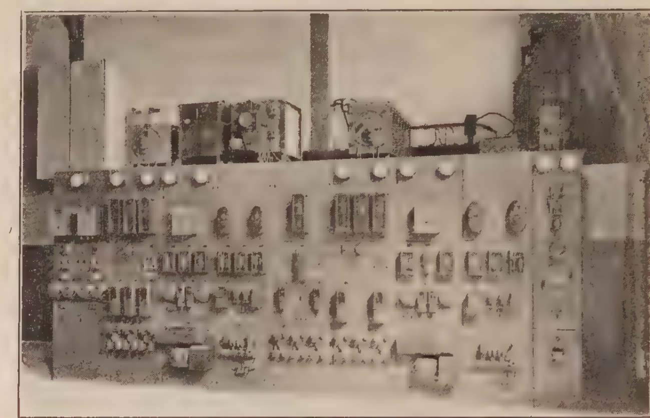

Fig. 15—New Orleans Public Service Co., New Orleans, La., Bourbon St. Station

Interior view showing automatic switching equipment for two synchronous motor generator sets, one 130/260 volts d-c. 1000 kw. and the other 260 volts d-c. 1200 kw.

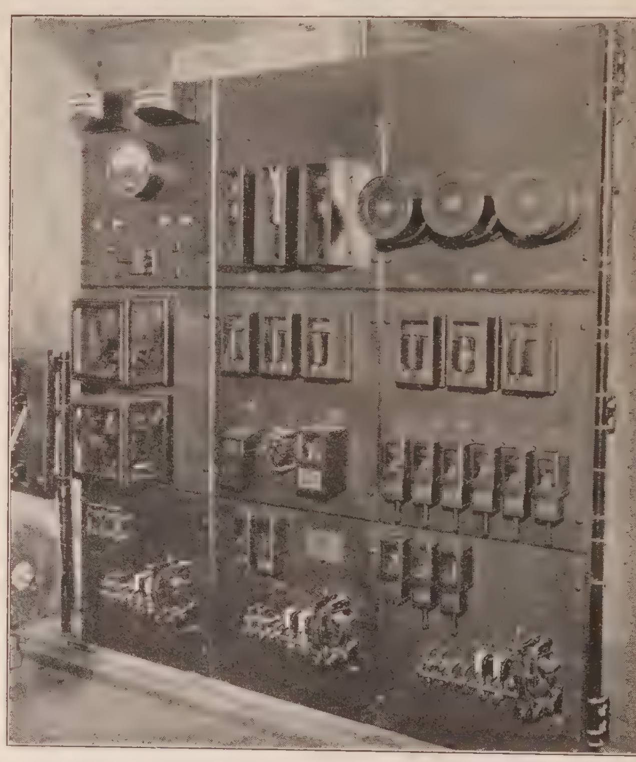

Fig. 16—Automatic Station Control Equipment, Kansas City Power ahd Light Co., Kansas City, Mo.

Instrument and relay panels for 1500-kw. 250-volt 3-wire synchronous converter (Front view).

noise being noticeable; that in an automatic station all the precautions are taken to prevent accident to the machine; that there is no operator to desert the machine when he is most needed; that the parts of the control can be located where there is physical space for them

and possibility of access for the inspector, even if the parts are distributed where hand operation would be cumbersome, if not impossible.

In locating such stations there is usually quite a wide latitude of location, since the station is being located in the midst of the load and the voltage drop to the feed points in the d-c. network will be low, the maximum length of run in most cases being at the most, two or three blocks.

Figs. 14, 15 and 16 illustrate such equipment.

The operation of automatic stations in metropolitan districts has, without doubt, increased the reliability of the service, by taking all the precautions against injury to apparatus without causing it to keep away from the legitimate load; by restoring interrupted service at the earliest possible moment; by making it possible to cut down losses by more frequent stations than would otherwise be economically possible and by allowing the operating force to devote their attention to maintaining the a-c. supply. It has proven economically possible to get this protection and to afford these facilities, because in so doing the reserve capacity in various branches of the equipment has been dispensed with, and equal or less money value put in protective features. The service has been improved by avoiding misunderstood instructions, experimenting by operators; mistakes in operation or in the interpretation of conditions. It has changed the work of a number of employees from the uninteresting work of waiting for something to happen in substations to the much more interesting work of maintaining such control and equipment.

Without a question the use of automatic substations will decrease greatly the labor turnover and the difficulties of the management from such causes. Above all, it will allow the management of a property to honestly say that every precaution which is now known has been taken to give continuity of service, and if accidents do happen, to restore the service at the earliest possible moment without depending on a series of people understanding instructions properly, rather than getting confused at the wrong time.

Hydroelectric Practises and Equipment on the Pacific Coast

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Review of the Subject.—*The paper takes up the physical features having deciding influence on design and construction of hydroelectric plants. It describes the mountain system of the region, the precipitation, the runoff, the streams suitable for power development, and the major characteristics of the development; then takes up a little more in detail the structural features, such as reservoirs and diversion dams, the conduit system, surge tanks and forebays, pressure pipes, power houses and equipment. The choice of impulse and reaction turbines is discussed and some performance curves given; this followed by conditions imposed upon modern plants by the transmission line; switch gear is briefly discussed followed by a resume on transmission lines and their control. Finally, some results which have been obtained are related, and the paper ends up with the hope that hydroelectric developments and distribution will continue as in the past, rather than have it undertaken by competing municipalities, which by ambitious advertising of cheap power (tax free) would endeavor to attract industries and people to their crowded areas.*

It is felt that the hydroelectric power industry on the Pacific Coast has distributed the benefits of cheap electricity to the small and large community alike, tending to more stable development of the entire region.

Mountain System

FROM north to south two parallel mountain chains, separated by great interior valleys, extend from the Canadian border nearly to the Mexican line. Along the ocean is the Coast Range, densely covered with forests in the northern part which gradually taper off towards the south and finally cease in the extreme southern portion where desert conditions prevail. About 100 miles inland is the more elevated and more massive mountain chain called in Washington and Oregon the Cascades and in California, the Sierra-Nevadas. The forest cover is here also much heavier in the north with the coniferous timber line gradually receding in the south where timber is found only at the highest elevations.

The two mountain chains merge into each other at two points, one in the Siskiyous in southern Oregon and northern California, and the second in the Tehachapi at the lower end of the San Joaquin Valley in California.

These mountain chains, together with the ocean, are the great actors in the distribution of precipitation over the land. The total range in precipitation is from less than one inch in the south to over 130 inches in the north.

Precipitation

Precipitation generally occurs when an area of low atmospheric pressure appears off the southern Alaskan coast and travels in a diagonal path southeasterly across

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the continent. This low pressure area draws, from the ocean to the south and southwest, air currents which have become heavily laden with moisture from contact with the ocean's surface. During the wet season the land is cooler than the ocean, southerly from it, and the wind, passing over the land, is cooled and gives up its moisture as rain or snow. Near the coast, with the exception of the higher mountains, the precipitation occurs chiefly in the form of rain, also as rain in the large valleys between the mountain ranges, and generally as snow in the Cascades and Sierras. In the south there is a decidedly wet and dry season, with the dry season much the longer, while in the north the difference between the wet and dry seasons is not so pronounced and the wet season is much the longer. There are modifications from local sources. Dry is summer; wet is winter.

Runoff

The runoff of the precipitated moisture from the mountain areas in influenced by the structure of the earth's crust, by plant growth, by form of precipitation (rain or snow), by temperature, wind and duration of storms. Some of these features are singly dominating in various sections. The most pronounced is in the lava fields of eastern Oregon and northeastern California. Much of this lava cover is porous to such an extent that there is very little surface runoff, the water at once sinking into the ground and appearing later in the stream channels well regulated by nature. In the granite Sierras there is a minimum of percolation, the heavy snow covers retard the runoff in varying degree, and this natural storage of water is highly important in maintaining stream flows well into the summer months. In the Cascades heavy humus covers and snow have similar effect.

Streams

The western slopes of the mountains receives a greater amount of moisture than the eastern. As a general rule, power streams flow west and the greatest number of large developed power sites are found on the western slope of the interior mountain range. There are exceptions to thus rule, of course.

South of the Tehachapi the streams have not sufficient flow to make any large power developments, but it is here that some of the early high head plants were built and much of the art was learned.

The largest rivers of the Pacific Coast are the Columbia and the Colorado. They have drainage areas far outside the region and have cut their way through the mountain ranges and plateaus to reach the ocean. These two streams have not been utilized on their main courses and are the great store houses of future power in the west.

Storage Reservoirs

Over a large part of the territory, the variation in stream flow has made storage reservoirs necessary for economical power production. The degree to which this has been carried has varied from a maximum in the southern part to a minimum in the regions of the lava-covered area. Also in the north, due to the better distribution and greater amount of the precipitation, the building of storage reservoirs is, at the present time, of relatively less importance than in the south. Storage will grow in importance with time, when streams will be utilized for a greater proportion of the average flow. South of the Tehachapi storage reservoirs have been built large enough to regulate stream flows for 10-year periods or more. The water is here, however, stored primarily for irrigation and whatever power can be had is considered a by-product. Further north in the granite Sierras the regulation of streams is often not complete and storage reservoirs within reasonable cost are relatively small. Here many reservoirs have been built for both power and irrigation, and as far as economically feasible, they have been dimensioned to regulate for the variation of stream flow of one season. The snow melts off uniformly by the end of June, quite independently of the amount. In dry years there is often a deficiency which must be made up by operation of steam plants.

Large reservoirs have been built in the Sierras for irrigation purposes, city water supplies and for storage of auriferous gravel after gold has been extracted by hydraulicing. Power is now generally developed through the head created by the dams and can as a rule be profitably disposed of to a nearby network of a utility.

In much of the Sierra territory water is extensively used for irrigation. The demand for power and irrigation does not coincide throughout the entire irrigation season and a certain amount of conflict exists. In some cases this can be remedied by after-storage and floodstorage at elevations below proper developments.

Character of Developments

A great variety of types of hydroelectric plants have been built in this large territory and each new location has its own peculiar problems to solve, governed principally by the following conditions and requirements: Topography, storage of flood water, size of the transmission network into which it feeds, size of the plant itself, loadfactor of the power market, time characteristic of the water supply, etc. For example, plants which have a natural uniform water supply are natural base-load plants, and those which depend on storage are built to handle relatively low-load factors in varying degree. The lower the load factor for which a plant may be built, the greater its construction cost per average unit of power, and a condition is approached where it pays to operate a steam plant to carry peak loads in conjunction with a hydro plant. The division of load between hydro and steam is best worked out by laws of economy.

Steam plants are further considered to have the important function to give service insurance for large load centers and to build up the load on a system during intervals of construction of hydro plants. The use of steam plants is not uniform over the entire area. Some of the utilities of eastern Washington get along without them. This is possible when the location of the water power is favorable, transmission short, and water supply certain every year, or the minimum flow is above the requirements.

Structural Features

Dams. Storage and diversion dams of all types have been built, the choice of type being generally determined by foundation conditions, available construction material, spillway requirements, overflow, and the psychological effect on human beings. The design of dams must now be approved by state authorities. The gravity type of masonry dam has been used here under similar conditions as elsewhere and recently built in large size for power, irrigation and water supply. The earthfill dam is often found and is characterized by the kind of material and method of construction. In regions favored with a good quality of uniform earth, the method is to spread the material in shallow layers and to compact them by wetting and rolling. With a material requiring segregation, the hydraulic-fill method is much in favor. Core walls are used, should more pervious material be encountered.

Since the cost of storage dams is a large item in the total cost of construction, the desirability for a reduction in cost has brought out some new types, namely, the multiple-arch dam and the constant-angle arch dam.

The multiple-arch dam consists of a number of inclined arches, resting on buttresses spaced uniformly across the site. The constant-angle arch dam is a single arch and is especially suited to a V shaped, rather narrow canyon. It is built up of a series of superimposed arch slices, which, as far as possible, are subtended by an angle of 133 degrees. This gives a minimum of masonry for a given unit of stress, considering the arch slices are uniformly loaded in a radial direction. This type of dam is in use with overflows as high as twenty feet. Both types require an unyielding rock foundation. The reduction in cost over a gravity type of dam is due to correct placing of the material to transmit the load to the foundations. In the gravity type the bulk of the material acts merely as weight.

Conduit System

Since the majority of the plants built are of the medium and high-head type, conduits or aqueducts are used to concentrate the fall of the stream at a favorable point. In some cases, such conduits are of considerable length, one, for example, being 24 miles long for a static head of 1900 feet, but in more favorable locations the same head may be created by a conduit of but a few miles in length.

The conduit system has undergone a certain amount of evolution, and types of structures have tended toward more permanent construction. The size of a conduit for economic power production is so determined that the annual charges, plus the value of the lost power due to friction, are a minimum. Closed and open conduits are used, each having its field. Where the climate is severe, with much snow and danger from slides, modern plants use tunnel, where less severe, pipe lines of steel, concrete or wood are used. The closed system may or may not be operated under pressure. Some plants have open systems, irrespective of above considerations, but generally the open system is used where the conduit is long and the climate mild.

When a conduit is of the closed type and not too long, it generally terminates in a surgetank; when of the open type, in a forebay. In a closed conduit the cross section should be large enough to carry the maximum load, which at any time may come on the plant. In the open conduit it need only be large enough to carry the average flow of water demanded during 24 hrs., the peak load being carried by the forebay.

Surge Tanks and Forebays

The closed conduit with surge tank has come into more general use during the last few years and the theory of the function of surge tanks in operation is now well understood. The tanks are given various shapes, depending on the selected duty cycle, which is given by the time characteristic of load changes and the general operating conditions of a system including accidents and the failings of operators. The difficulty in selecting the proper surge tank is not so much with the theory as it is with the duty cycle. It has been built as a plain cylinder, a truncated cone right side up or inverted, or of the shape of an hour glass.

Forebays in connection with open canal systems of considerable length are, if possible, made larger than required for 24-hour regulation, in order to give service insurance, should the conduit system become inoperative due to snow or landslides, etc.

Pressure Pipes

In most developments the pressure pipe is a considerable item on the total installation and for high heads and long lines it is one of the most important ones, and is given very careful consideration in design, installation and operation. In the great majority of cases and nearly always for heads greater than 150 feet, the pressure pipes are made of steel. Wood stave pipe has been used to some extent and concrete pipes are few. A combination is sometimes used of wood-stave construction in the upper part and steel below. Skill and care are required in the installation of wood-stave pipe and, if properly done and the staves kept completely saturated, the pipe will give service for an

indefinite time. It is preferred to keep the staves away from the soil by means of cradles of concrete or durable wood (cedar and redwood). Steel pipes are either riveted or hammerwelded. Riveted pipe has been used since the beginning and given excellent service. The welded pipe was imported to a small extent before the war, but is now made in this country, and some of the recently built plants have used this type for both high and medium heads.

In pipe of large diameter and light or medium metal, the loss in head, due to friction, is about equal for the two kinds of pipe, but when riveted pipe is small in diameter and the metal heavy, the space occupied by straps and rivetheads is relatively large and the loss greater than for welded pipe which has flanged joints and presents a smooth bore throughout.

Welded pipe is installed with greater ease and, due to the fact that expansion joints can readily be furnished with the pipe and of the same material, it need not be buried. Being above ground, its condition from the outside is always known and repair and painting work greatly facilitated.

Riveted pipe is often installed in an excavated trench and expansion joints are not required. Some installations, with pipe partly buried, use expansion joints of built-up material which have given good service.

Anchors and their location are of much greater importance with the pipe above ground than with pipe buried. Pipe lines without expansion joints are suited best to a broken profile and horizontal angles; pipes having expansion joints are suited best to a straight course between intake of pipe and turbine.

Long pipe lines contain moving water columns of thousands of tons weight which must never get out of control. If control is lost, disaster is swift and certain. Aside from the control obtained through the governor, stop-gates or valves are placed in long lines both at top and bottom. For short lines and single-unit plants the valve at the bottom is sometimes omitted. In the older plants the gates at the top were simple devices often made of wood; in later plants valves have been introduced directly in the pipe line, just after leaving the forebay or surgetank. Both slide valves and butterfly valves are used, and the latter seem to be gaining in favor and so far have given very good results. The butterfly valve is sufficiently tight when carefully made, and the body of its closing disk can be made of efficient form with respect to the flowing water. At the power house end slide valves, butterfly valves and plunger valves have been used with uniformly good results, with the exception of the control for the plunger valve, which has not been positive and powerful enough to the degree required by the high pressures and long lines used here.

Power House Equipment

Turbines and Waterwheels. Until a comparatively few years ago, plants in the southern half of the territory used the impulse turbine almost exclusively, while in the northern territory, due to more moderate heads, the reaction turbine was generally used. A turning point came with the installation of the Centerville turbine in 1906, which was the pioneer high head machine (559 ft.) with a maximum capacity of 9000 horse power. Since then reaction turbines have continued to extend in use for the higher heads which were formerly covered by the impulse turbine. The reason for this change is the better efficiency which may be obtained and the full use of the available head by means of the draft tube.

With the higher heads, the reaction wheel is exposed to a great pressure difference between inlet and outlet of the runner, and manufacturers give much attention to details of the leakage path. A recent development is the rubber seal ring.

There has been some trouble from vibrations in large reaction turbines, indicating that the water passages do not transform the energy correctly. There may be many causes for this, but it would seem that a turbine must be carefully proportional to give its output at best efficiency with the amount of water available; not for example with one and one-half times this amount, for if the additional water is to be had only occasionally, the turbine at all other times is working with a poor efficiency. Draft tubes may be the originators of much of the vibration and although there has been great improvement in draft-tube design, some draft tubes do not give the correct impression when viewed in action on large units. Whatever the swirl of the water in the draft tube may be, the tendency to form vortices should be suppressed completely.

The impulse wheel will probably hold its place for heads above 1000 ft. for a long time to come, units of 30,000 horse power are in use at that head, but conditions for best efficiency improve with increasing head. Some efficiency curves were given for both types of wheels to show what is being accomplished at these high heads, in complete paper. The impulse wheel is used for units of small capacity at much lower heads; they have few moving parts and are rugged in these sizes and for that reason preferred for exciter drive.

The governing of impulse wheels is accomplished in different ways. The jet may be deflected by movement of the nozzle body itself, or by a jet deflector which cuts into the stream, or by movement of the needle. When the movement of the needle is under the control of the governor, an auxiliary nozzle is added, the needle of which is opened when the main needle closes to follow a reduction in load. The closing of the auxiliary needle takes place at a predetermined and adjustable rate through the intervention of a dashpot and heavy springs.

Generators. 60 cycles is the standard frequency with the exception of a large utility in the south. This utility uses 50 cycles, but has some equipment suitable for both 50 and 60 cycle operation.

The mechanical arrangement of generators is given by the prime mover and is in all respects similar to installations elsewhere.

As transmission voltages increase and lines become longer, a certain number of the generators of a hydro-electric transmission system are required to handle the charging current of an unloaded line. This charging current is a magnetizing current which produces a field superimposed on the field of the rotating direct currents magnets and in phase therewith. The excitation from the exciter machines is therefore lowered for this condition as much as possible, yet it must be positive and definite. The sum must not be great enough to raise the voltage further, which would increase the charging current and build up a still higher voltage. The resulting kv-a. load on the generator must not exceed its capacity.

It has been proposed for many years, and it is now

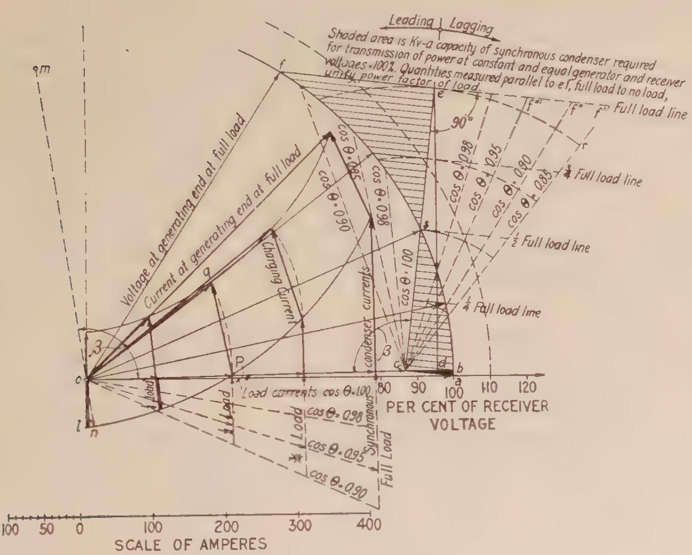

FIG. 1—REGULATION DIAGRAM FOR TRANSMISSION LINES

becoming common practise, to protect generators against internal electrical breakdown by means of balanced relays. Governors are usually provided with a load-limiting device, and in addition, when a fault develops in the winding, they are actuated to automatically close the turbine guide vanes to reduce the flow of energy to the fault.

Switch Gear. All low-tension switch gear, as well as its arrangement, is of the same design as found elsewhere in the country. In some recent installations all oil switches between the generators and transformers are omitted, resulting in remarkable simplicity. The isolated-phase system has not yet been employed.

The high-tension gear is more and more being installed out of doors for potentials of 110 kv. and higher, and with properly selected insulations, results have been good. The oil switches and breakers for high voltages assume truly large proportions, and the quantity of oil they contain may be as much as for a 20,000-kv-a. transformer. Most of these oil switches have two breaks per pole, some have four or more, and the movement of the contacts may be either vertical or horizontal. Switches are in use with or without the so-called explosion pots. High-tension oil switches may be due for some improvement; they are fitted with ponderous mechanisms and have slow acceleration of moving contacts. It is not expected that the size of oil-switch containers can be much reduced, because of the a priori requirement for electrical clearances.

The chief reason for placing the high-tension gear in the open is of course the reduction which may be obtained in first cost, due to the elimination of large housing structures. Some companies use an arrangement whereby a high-tension oil switch may be by-passed by means of disconnecting switches, so that the line may be kept in service while the switch is isolated for inspection, cleaning and repairing. High-tension oil switches and disconnecting switches have been manufactured on the Coast for many years, which is the result of a need made necessary by the early high-tension transmission lines in California.

Transformers. With the higher voltages and where it is not too difficult to provide the necessary space, transformers are often installed out-of-doors with the high-tension switch gear.

The grounded 3-phase transmission system is almost universally used, the desire being to secure a stable neutral and fixed potentials from terminals to neutral. The transformers are almost exclusively single-phase, and generally at generating end transformers are two-winding with delta connection on the low-tension side. Usually both terminals of the high-tension windings are brought out, but in some recent high-voltage work one terminal was grounded to the case, so only one terminal is conspicuous through the high-tension bushing. At the receiving end both two-winding and three-winding transformers are used, depending upon connections to other high voltage lines. If connected to other high-voltage lines, the three-winding arrangement is required for star star connected auto transformers, the third winding serving for circulation of the single-phase triple-harmonic currents and for operation of synchronous condensers. In extra high-voltage work the space required for insulation and electrical clearance from winding to winding, becomes larger and the electro-magnetic interaction of the windings is influenced thereby, and particularly for transformers with a number of taps, care is required in the design to secure the desired regulation and potential distribution. The two-winding transformer is better off in this respect than the three-winding transformer, and an endeavor is being made to reduce to a minimum the number of taps on important transformers.

TRANSMISSION LINES

Insulation of high-tension lines has received a renewed and rather extensive investigation, due to the

advent of the 220-kv. lines. This work has not ended, and the companies are engaged in collecting facts concerning the operation of this last development in transmission.

High-voltage lines are controlled by aid of rotating synchronous machinery, located at terminal substations. For this purpose there is installed and under order on the Pacific Coast at least 300,000 kv-a. in synchronous condensers. At the present stage of the transmission art, some of the lines could not be controlled in any other way. A simple diagram is given in Fig. 1, by which a clear vision is obtained of the factor involved in the control of high-voltage lines. A description of this diagram was given in the A. I. E. E. PROCEEDINGS, 1922, page 790, the notation is the same. High voltages are necessary, as it is not possible to transmit large blocks of power economically over long distances in any other way.

Tooth Pulsation in Rotating Machines[1]

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Review of the Subject.—1. *An experimental method is presented of checking the magnitude of flux pulsations in the teeth of rotating machines where both members are slotted. The method consists in using metallic electrodes shaped like the teeth of a machine and an electrolyte or mercury to represent the air. Voltage is applied between the two members and the current through the tooth under consideration is measured. The magnitude of this current under different conditions is proportional to the magnitude of the flux which would flow under the analogous magnetic conditions.*

2. *The test results are compared with the pulsation amplitudes as calculated by two methods. The test results are in general slightly lower than the calculated but the agreement is fairly good.*

3. *It is believed that either of the above-mentioned methods can be used to calculate tooth pulsations without serious errors where saturation effects are not appreciable. These methods should be specially useful in determining which of two or more designs would be subject to the lesser pulsation losses.*

4. *The effect of saturation in the iron is determined experimentally by making the ratio of the mercury to the electrode resistance small. This ratio corresponds to the magnetic permeability. The effect of the tooth resistance on the amplitude of the pulsation is calculated by assuming three resistances in series, namely, the stator and rotor tooth resistances and the air gap resistance. The calculated and test values check reasonably well.*

5. *It is shown that the effect of saturation on pulsation amplitude for actual machines can not be calculated by adding directly the air gap and tooth reluctances due to the fact that the permeability of iron is not constant. In order to actually calculate the effect of saturation, it is necessary either to plot portions of the magnetization curve or to make use as we do of the incremental permeability values.*

6. *The method described of allowing for saturation is too complicated for ordinary design calculations but is useful in giving a clearer picture of just what these effects are and could be successfully used for special cases where the extra labor involved was warranted.*

7. *These methods do not apply when short-circuited windings are present in the slots. It is hoped at a later date to consider this aspect of the problem.*

8. *We believe it is possible by the use of the outlined methods below to calculate simple, reasonably reliable correction curves for saturation effects which may be used both for the case of uniform mean flux and for a sine distribution of the mean flux.*

INTRODUCTION

WHEN the rotor and stator of a rotating machine are both slotted, high frequency flux pulsations are produced in the teeth which give rise to hysteresis and eddy-current losses. These losses may amount to a considerable percentage of the total core losses of the machine. In order to predetermine the magnitude of the losses and to reduce them to a minimum by proper design it is first necessary to be able to calculate the magnitude of the tooth pulsations. These pulsations are the result of local changes in the air-gap reluctance and are reduced by saturation effects in the iron of the teeth; namely, when the reluctance of the teeth is appreciable with respect to the reluctance of the air gap the tooth pulsations are less. Also the presence of short-circuited windings in the slots such as in the case of rotors of squirrel-cage induction motors or the damper windings of salient-pole machines tend to reduce these pulsations. These latter effects, namely, of short-circuited windings, will not be considered in this paper but it is hoped that at a later date we may deal with them also.

EXPERIMENTAL METHOD

In order to determine experimentally the magnitude of the tooth pulsations, use was made of the analogy between the flow of electric currents and the distribution of magnetic flux. A set each of copper and brass blocks were machined from solid material having the dimension shown in Fig. 2. The thickness was ½ inch (1.27 cm.). A tray was filled with paraffin wax with an opening left large enough to take a set of blocks arranged as shown in Fig. 1. The sides of the opening are shown by the dotted lines. Electrical connections were made to the blocks as indicated.

The principle of operation is as follows, tooth D

1. This is one of a number of articles being published by members of the Core Loss Committee of the National Research Council.

Abridgement of a paper presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., February 4-8, 1924. Complete copies to members on request.

being the one under test. It will be noted that block D is electrically separated from A in order that the current flowing into it may be measured. The openings between the blocks are filled with an electrolyte or mercury so that its level is just flush with the top of the blocks. The blocks represent the iron teeth of a machine and the liquid represents the air. The ratio of the resistivity of the liquid to the resistivity of the block material gives the effective permeability. All we have to do then is to measure the current flowing into the block D for various conditions and this will be equivalent to the flux which will flow under the corresponding magnetic conditions, since the current corresponds to the flux and the voltage to the magnetomotive force. It will be seen that with the arrangement shown in Fig. 1, we have a maximum reluctance or resistance between tooth D and the teeth of the block B. Now if we remove block B and substitute block C (Fig. 2) we shall have the condition of minimum resistance. This change of blocks corresponds to a movement of the stator with respect to the rotor of one-half a slot pitch. The tests are made on the assumption of constant difference of magnetic potential between the stator and the rotor yokes and this corresponds to a constant electromotive force between points b and c.

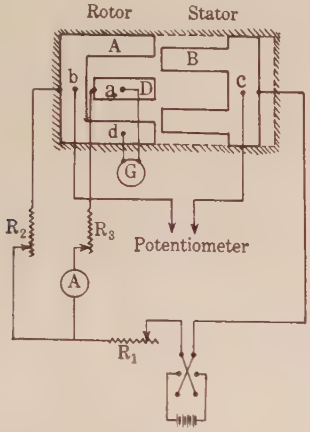


Fig. 1—Diagram of Connections for Tooth Pulsation Tests

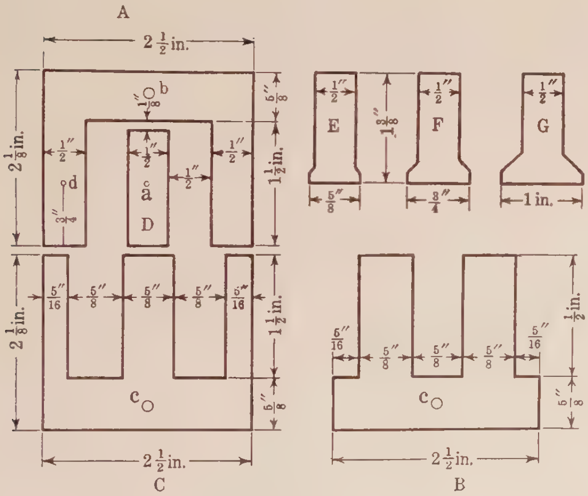


Fig. 2—Copper and Brass Blocks for Tooth Pulsation Tests

If we use an electrolyte it will be seen that for all practical purposes its resistance is infinite with reference to the resistance of the copper or brass blocks. This will correspond then to the condition of moderate and low inductions in the teeth in which the permeability of the iron is many times that of air.

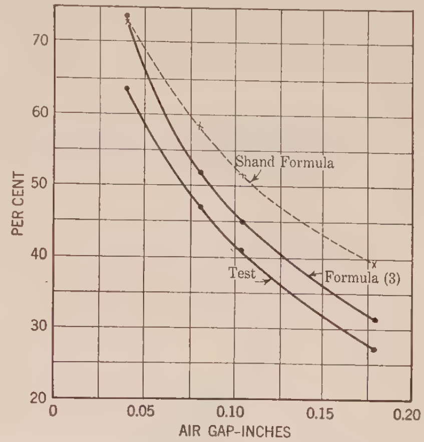


Fig. 3—Test and Calculated Tooth Pulsations for Tooth D and Infinite Permeability

If, instead of an electrolyte, we use mercury with the copper blocks, for instance, we obtain a ratio of resistance of the copper to the mercury of approximately 55.5, which will be equivalent to a permeability of this value. By using brass blocks and mercury we obtain an effective permeability of 13.6.

With an electrolyte of course it was out of the question to use direct current so we went to a 500-cycle supply. In place of the galvanometer G, we used a telephone receiver and for the ammeter a thermo-electric instrument. Voltage was maintained constant by means of a Paul voltmeter placed outside of the ammeter A. Suitable corrections were made for the change in voltage due to the $I\,R$ drop in the ammeter. The resistance R_3 was eliminated.

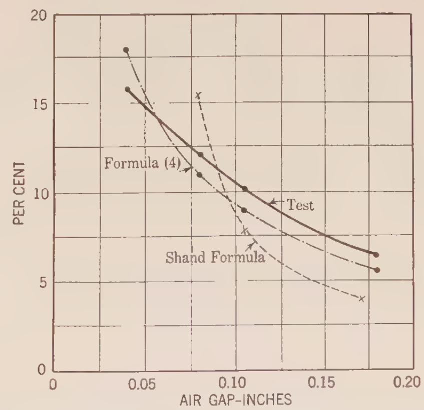


Fig. 4—Test and Calculated Tooth Pulsations for Tooth G and Infinite Permeability

Test Results

Typical test results are given in Figs. 3-4 plotted

between per cent pulsation based on the maximum current or flux and the air gap in inches. These curves are for infinite permeability. Fig. 5 shows the curve for tooth D and a permeability of 55.5, and Fig. 6 the corresponding curve for a permeability of 13.6. Fig. 7 gives a comparison between the test and calculated values for an air gap of 0.04 in., (1.01 mm.) and various permeabilities. Fig. 8 gives similar results for an air gap of 0.180 in. (4.57 mm.). Fig. 9 shows the relation between air gap and per cent pulsation of tooth D and the three permeability conditions.

Method of Calculating Pulsations

Some time ago we devised formulas for calculating tooth pulsations making use of Carter's fringing constants which apparently work very well. Hoseason[2] has recently suggested the use of such a method but did not go into details as to how to apply it. Our method is as follows. Referring to Fig. 10, suppose we calculate the effective width (t_e) of the stator and rotor teeth by using Carter's fringing constants[3] and assume that all the flux crossing the air gap is confined to those widths and that it is of uniform density. Suppose that we also assume that the flux flows only over those portions of the effective tooth widths which happen to be opposite each other. Now by calculating the change in tangential air gap widths opposite each other for the position of maximum and minimum reluctance, we can estimate the amount of the tooth pulsations. When Carter's coefficients for the stator and rotor teeth have already been calculated for other purposes, the effective width of the tooth may be obtained from the ratio $\lambda / g = (t_e)$ where λ is the tooth pitch and g is the Carter coefficient.

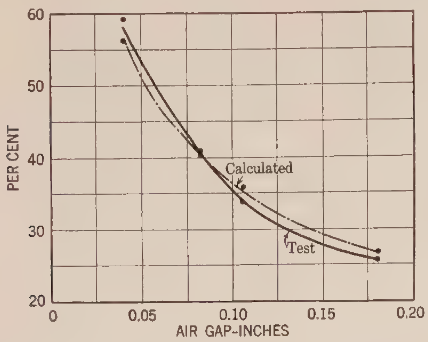


Fig. 5—Test and Calculated Tooth Pulsations for Tooth D and a Permeability of 55.5

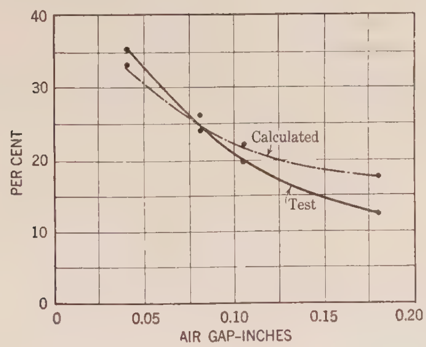


Fig. 6—Test and Calculated Tooth Pulsations for Tooth D and a Permeability of 13.6

Referring now to Fig. 11 we have the four cases which are likely to occur in practise for induction motors. The stator tooth pulsations in per cent of the maximum flux can almost always be calculated by the formula (open stator slots).

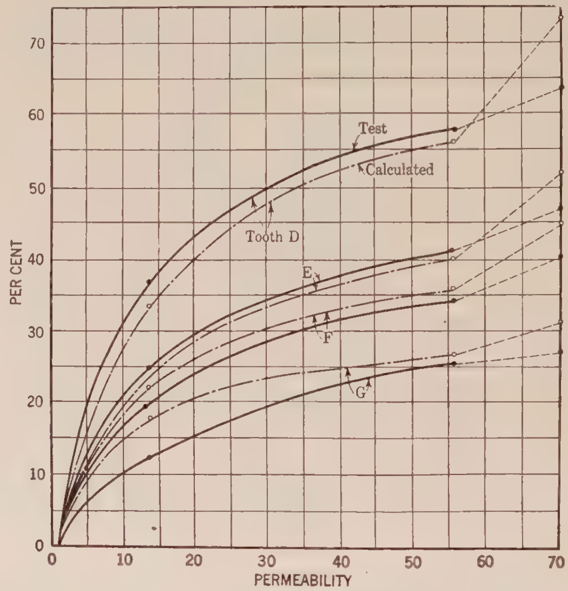


Fig. 7—Test and Calculated Tooth Pulsations for Various Teeth and Permeability and an Air Gap of 0.04 Inches

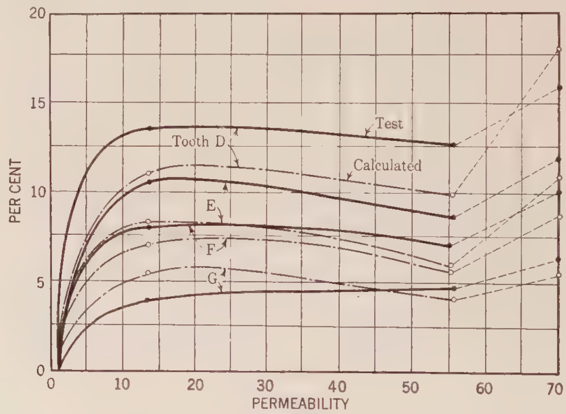


Fig. 8—Test and Calculated Tooth Pulsations for Various Teeth and Permeability and an Air Gap of 0.04 In.

$$P_s = \frac{\lambda_r - t_{er}}{t_{es}} 100 \qquad (2)$$

There are four cases for the rotor teeth depending on the relative dimensions. These four cases are covered by the following formulas:

Case 1 — Limits

$$P_{r1} = \frac{\lambda_s - t_{es}}{t_{er}} 100 \qquad (3)$$

P_{r1} cannot exceed 100

t_{es} is greater than t_{er}

2. Tooth Frequency Iron Losses in Slip Ring Induction Motors, D. B. Hoseason; *Electrician*, Sept. 7, 1923.

3. Electrical Machine Design. Alexander Gray; p. 44, fig. 40.

Case 2

$$P_{r2} = \frac{\lambda_s - t_{er}}{t_{es}} 100 \qquad \begin{array}{l} t_{es} \text{ is less than } t_{er} \\ P_{r2} \text{ has a positive sign} \end{array} \qquad (4)$$

Case 3

$$P_{r3} = \frac{t_{er} - \lambda_s}{t_{er} - \lambda_s + t_{es}} 100 \qquad \begin{array}{l} t_{es} \text{ is less than } t_{er} - \lambda_s + t_{es} \\ t_{er} \text{ is less than } 2\,\lambda_s - t_{es} \end{array} \qquad (5)$$

Case 4

$$P_r = \frac{\lambda_s - t_{es}}{t_{er} - \lambda_s + t_{es}} 100 \qquad \begin{array}{l} t_{er} \text{ is greater than } 2\,\lambda_s - t_{es} \\ t_{er} \text{ is less than } \lambda_s + t_{es} \end{array} \qquad (6)$$

where,

P_s is the stator tooth pulsation in per cent of the maximum tooth flux

P_{r1}, P_{r2}, P_{r3} and P_{r4} are the rotor tooth pulsations for the four cases

λ_s is the stator slot pitch

λ_r is the rotor slot pitch

t_{es} is the effective stator tooth width

t_{er} is the effective rotor tooth width

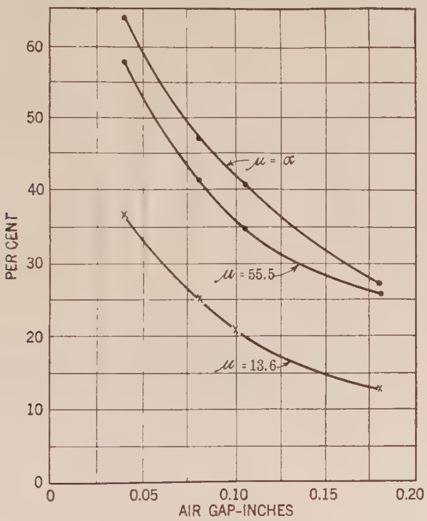


Fig. 9—Test Tooth Pulsations for Various Air Gaps and Permeabilities for Tooth D

Cases 1 and 2 are to be used when the rotor slot pitch is less than the stator slot pitch and cases 3 and 4 when the reverse is true. The conditions for the four cases are shown graphically in Fig. 11. If the rotor slot pitch becomes greater than covered by case 4, a fifth and sixth case, etc., may be added if necessary but the above four cases will cover practically all commercial conditions. After the effective tooth widths are calculated it takes only a moment to determine which formula to use.

Saturation Effects in Actual Machines. In order to calculate the saturation effects in the teeth of actual machines it would seem at first glance that it is simply necessary to add the reluctance of the teeth to the reluctance of the air-gap for the positions of maximum and minimum air-gap reluctance, calculate the total change in reluctance due to the change in air-gap reluctance for the tooth under consideration and then take this difference as a measure of the tooth flux pulsation. This procedure would be correct if the permeability of iron were constant. Since this is not the case, however, the method is far from valid. Again from permeability curves on commercial sheet iron it may be seen that it is necessary to go to inductions of over 120 kilolines per sq. in. before we reach a permeability as low as 100. According to the data just

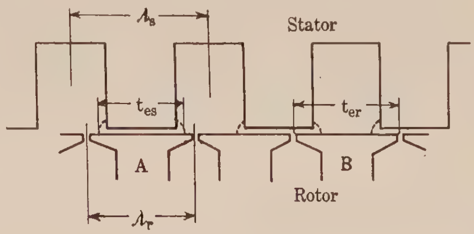


Fig. 10—Sketch Showing Method of Calculating Rotor Tooth Pulsations

reported (see Fig. 9) a permeability of even as low as 50 does not very greatly affect the pulsation amplitude and yet we know from tests on actual machines that saturation effects begin to be noted at tooth inductions of about 70 kilolines per sq. in. where the permeability may be several thousand, and at 120 kilolines these saturation effects are quite large. The following analysis will make clear the reason why these saturation effects appear at such low flux densities and will also give a method of calculating them.

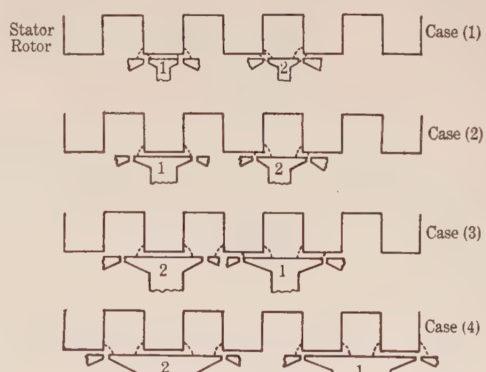


Fig. 11—Sketch Showing Method of Deriving Tooth Pulsations Formulas

Referring to Fig. 12c, let us assume two teeth opposite each other having the dimensions as indicated. These dimensions may be in any desired units provided the units are all the same; d_r is the effective length of the rotor tooth and is somewhat less than the actual length to take care of the wide tip which does not saturate: t_{es} is the effective tangential width of gap and is equal to t_s (actual stator tooth width) plus Carter's fringing constant times the stator slot width as above. Now referring to Fig. 12a the ordinate represents the total

flux per tooth across the air gap and the abscissas the magnetomotive force necessary to force this flux through the various parts of the path from the root of a stator tooth to the root of a rotor tooth. The magnetomotive force m is that necessary to force the flux across the air gap from one tooth to the other and is equal to the flux times the air-gap reluctance R_δ where the air-gap reluctance equals the radial air-gap width δ divided by the effective tangential air-gap with t_{es}; n is the magnetomotive force necessary to force the flux through the stator and rotor teeth and is equal to $\phi \times R_f$, where R_f is the total tooth reluctance. The tooth reluctance must be calculated separately for a stator and rotor tooth and is equal to

$$\frac{d}{\mu \times t} \tag{15}$$

d is the effective length of tooth,

μ is the permeability corresponding to the maximum induction and t is the width of the tooth. The sum of the reluctance for the two teeth gives R_f.

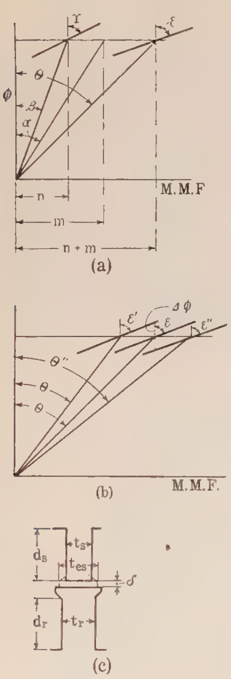


Fig. 12—Sketches Showing Method of Calculating Effect of Saturation on Tooth Pulsations

Now referring to Fig. 12A, suppose we assume some arbitrary flux and plot a point corresponding to this flux and to the magnetomotive force $= \phi R_\delta$. Draw a line from this point through the origin and call the angle made by this line with the vertical α. Now the tangent of this angle is,

$$\frac{\phi \times R_\delta}{\phi} = R_\delta \tag{16}$$

and is proportional to the reluctance of the air gap. Similarly the tangent of the angle β is R_f and is proportional to the reluctance of the teeth. Suppose now we increase or decrease the flux ϕ. The line making the angle α (air-gap reluctance) will simply be extended. If, however, we consider the line making the angle β (tooth reluctance), when the flux is increased the line will not be extended but will follow a curve corresponding to the magnetization curve for the steel. In order to simplify this instead of plotting a magnetization curve, let us consider that the flux follows a straight line, making the angle γ with the vertical. This angle γ is calculated in the same way as the angle β except that we use the incremental permeability $\mu\,\Delta$[4] instead of the ordinary permeability. The incremental reluctivity $R_{f\Delta}$ is the sum of $\frac{d}{\mu\,\Delta \times t_f}$ for the two teeth. This simply means that we are assuming that over the range of inductions covered by the tooth pulsations the magnetization curve is a straight line which is the line connecting the two tips of a minor hysteresis loop, having the same flux amplitude as the tooth pulsations and whose upper tip corresponds to the maximum tooth induction.

Now if we combine the air gap and tooth reluctances we obtain a line making an angle θ with the vertical and the tangent of the angle will be $R_\delta + R_f$ and the tangent of the angle ϵ will be $R_\delta + R_{f\Delta}$.

Now referring to Fig. 12B the angle θ is the same as for 12A, namely, at the assumed flux the magnetomotive force equals $R_\delta + R_f$ where R_δ is the mean reluctivity of the air gap. If now we calculate the tooth pulsations by the appropriate formula (3)-(6) and make R_δ' one-half this per cent less than R_δ and R_δ'' the same amount greater we may calculate the tangents of the angles δ', δ'', ϵ', ϵ'', as shown by Fig. 12. Now if we draw a vertical line through the point of intersection of the line of θ and the assumed flux the length of this line $\Delta\,\phi$ (Fig. 12B) between the lines of ϵ', and ϵ'' will be the flux pulsation or will give the per cent pulsation numerically if the maximum flux is assumed to be 100.

This correction for saturation applies only for the teeth in the position of maximum induction. In the case of an induction motor where the flux varies approximately according to a sine wave, the saturation effects will be different for every flux value and this greatly complicates the correction. The actual use of this method is more difficult than indicated in the example due to the presence in commercial machines of tapered teeth, to appreciable leakage fluxes through the slots at high inductions and various other disturbing factors. We believe, however, that for careful machine design the method is valid and may be employed with confidence when the extra labor involved warrants its use. These pulsation calculations are correct only when short-circuited windings are not present. For the case of the squirrel-cage induction motor and the salient-pole machines with damper windings, corrections will be necessary for the counter-magnetomotive force of the short-circuited windings.

We have calculated saturation correction curves based on different relative tooth widths, lengths and air gaps for the case of induction motors. These curves have not been adequately checked experimentally and will not be included here. We hope, however, that they will prove to be reasonably accurate and if they are, will make a ready method of correcting for saturation effects in wound rotor induction motors.

4. Permeability. Thos. Spooner: A. I. E. E., Journal, January, 1922.

Operating Problems of the Railroads

Addresses and Discussion at Transportation Meeting Held at Mid-Winter Convention of A. I. E. E., Philadelphia, Pa., Afternoon of February 5, 1924

ADDRESS BY L. G. COLEMAN

Assistant General Manager, Boston and Maine Railroad

I HAVE been asked to tell you some of the problems that today confront the railroad operating officer.

There are many but in my opinion there is one that transcends all others in importance, and I propose to confine my remarks to a few of its manifestations.

It can best be described as "lost motion." There is, of course, the inevitable lost motion inherent in all large business organizations. It is fully recognized and constantly combatted. I am going to discuss only lost motion that may be overcome by improved physical appliances, or improved use of those existing, particularly the idle time of locomotives and freight cars.

What I believe will interest you most is the problem that has developed from our efforts to decrease transportation costs with heavier and more economically operating locomotives.

I wish to make clear at the outset I am the last one to condemn the adoption of larger and improved units. They have been the means of great reductions in transportation costs. As much freight can be moved by the modern locomotive with five trainmen as could be done with nine to twelve by those of 1900. The saving in fuel per unit is probably at least 35 per cent; the capacity of main lines is much increased. The economies have been real and large. The point I intend to emphasize is that the costs to accomplish this must have more consideration, and unless our road economies are to be eaten up in the stable we must give these costs most serious attention.

Had it not been for these modern locomotives the railroads of the country would have been swamped long ago, but there is a very real corollary to their adoption, the seriousness of which is only beginning to be understood.

From 1900 to 1923 the average freight revenue per ton mile in the United States has increased about 48 per cent. In 1900 the cost of the average standard freight locomotive was about $12,000. It was a simple saturated-steam mogul or consolidation type, with reasonable axle loads, had two injectors and a simple 9 ½-inch air pump; hand sanders and a rope to pull the bell; nothing much to get out of order and easy to fix if it did. It was a hog for punishment; also for coal and water, but they were cheap then. It was available for service about 75 per cent of the time and this percentage of availability is an important factor.

The cost of a modern up-to-the minute freight locomotive is about $70,000. It is a Mikado or Sante Fe, superheated, with axle loads well up to the limit, and consequent heat troubles; automatic sanders and bell ringer, compound air pump, automatic fire door, power reverse gear, power grade shaker, ashpan blower, electric headlight, feed-water heater, stoker, booster, flange oiler, and at times a soot blower and a coal pusher. Most devices to save coal and water and to increase tractive effort are expensive, and require constant inspection and adjustment which means time even when no repairs are necessary. We are now watching for three cylinders as the next step. The new type of locomotive is available for operating service about 45 per cent of its time, instead of 75. Its tonnage capacity is about 2 ⅓ to 2 ½ times that of the locomotive of 1900.

The cost of the increased roundhouse facilities to take care of such a locomotive is about four times what it was. The cost of shop facilities has increased at least in proportion and probably more. The cost of maintenance per ton mile has more than doubled. These figures are only general and are taken from the result of operations during Federal Control when we had fairly complete records and from various results on individual railroads since. You can verify them by a check on any standard railroad. You can see from this that the capital and maintenance cost of power to move a ton of freight a mile has increased at a much more rapid rate than the revenue and consumes a large fraction of transportation savings due to road economy. We are approaching a point where this fraction may be a major part of the whole. When you consider that a modern steam locomotive costing seventy odd thousand dollars is available for service to move freight only 45 per cent of the time, the problem is apparent. The more we endeavor to increase operating efficiency the greater the lost time, or lost motion. This condition has been and is being seriously considered from various angles by many railroad officers. There is an opportunity to increase the available time possibly 10 per cent, some even believe 15 or 20 per cent, but at a cost that is staggering to many of us.

Let us assume an imaginary railroad with a gross freight revenue of forty million dollars; with an operating ratio of 75 per cent; net ten million dollars. Six million dollars would buy the necessary freight power on the old basis, with money then at 5 per cent.

To move the same freight entirely with modern locomotives considering cost, tractive effort, and availability, would take fewer units but the investment would be twenty-four million dollars, with money at 6

per cent. This yearly charge to pay out of the net revenue to move the same freight is 18½ per cent greater than formerly.

I can remember twenty odd years ago when I had charge of two engine divisions, each slightly over 100 miles in length, on which we were moving daily 600 to 700 cars of freight in each direction. We had a fleet of 20-in. by 26-in. saturated-steam simple mogul engines. It was the custom for the train dispatcher to notify the roundhouse of the probable time of arrival of all engines on through freight trains and for them to be called for departure two hours after their expected time of arrival. It was understood that if there was anything wrong with the locomotive which would prevent its turning on arrival the engineer was to notify the dispatcher from the last water station, about two hours out. In absence of such notification it was assumed that the engine would turn on arrival. It is a fact, the correctness of which I have verified by looking over some old diaries of mine, that at least 65 per cent of the freight engines were turned in two hours at both ends of the line; or, in other words, 65 per cent of the time they were ready to turn; 35 per cent of the time they required repairs. I don't know how familiar you are with modern railroad operation but I can tell you that with the modern Sante Fe or Mikado locomotives equipped with all the economical attachments of the present day, such an arrangement is out of the question, and if tried I feel safe in saying not 10 per cent of them could so turn. When you consider the interest, depreciation, and maintenance of power that costs to move a ton of freight over four times what it did in 1900, as well as the cost of the plant to take care of it, you can appreciate the lost-motion problem.

Let us recapitulate some of the reasons why our modern locomotive will not turn in two hours. I have already described the simple machine we had in 1900. There could not be much the matter with it that could escape the engineer. He was able to report its condition after a superficial inspection, and the ordinary ills could be quickly cured. But now! I have told you of twelve additions to the equipment. Here is what it means. There are from 150 to 200 ground joints in the superheater; fortunately they do not often require attention but mean a day when they do; 69 moving parts, such as valves and pistons, all concealed; 11 additional steam and four air valves in the cab. You can imagine how much the engineer on the road can say about the condition of the locomotive. The time taken to inspect this apparatus at terminals must be apparent.

Our problem can be likened to that of a supposititious manufacturing plant which in 1900 ran its machinery for twelve hours and could upon occasions run it eighteen hours a day without necessity for stopping for repairs or adjustment, and today has a new plant full of the latest labor and time-saving machinery but restricted to an eight-hour day on account of the necessity of using the remaining sixteen hours to repair and adjust the machinery for the eight-hour productive period. In order to double the output of the plant it would be necessary to build an entirely new one, using the first plant only eight hours a day. This should give you some idea of the railroad locomotive situation.

There is also one interesting comparison directly brought out by the above statement. There are very few manufacturing plants that cannot work continuously so far as their machinery is concerned with reasonable shutdowns for repairs. Such a situation, however, is impossible on the railroad as its machinery and power are combined in the same unit. This, I believe is one of the fundamental differences between manufacturing things and manufacturing transportation.

There is, I believe, a very wide field for engineers of all denominations in which to help with this problem. The most hopeful ground for improvement is the forty-five per cent availability of the modern locomotive. It has already been attacked by the lengthening of engine divisions but this is not enough. We must go further and devise means of speedier turning if the modern steam locomotive is to hold its place as the principal mover of railroad freight. We must get a quicker turnover of our money. It is a serious engineering problem requiring the best brains of the profession.

Don't misunderstand me—the development of the modern locomotive has been along the only available lines and those responsible deserve great credit. But we have reached the end of the road—mere increase in size and power will no longer answer—we must begin to refine—present axle loads cannot well be exceeded.

I am now going to soar a little. Please do not judge the soundness of my remarks about the modern locomotive by what I am about to say. I feel up to the present my feet have been pretty firmly on the ground. I am not so sure either one will be touching from now on. The clouds look interesting anyway, so I will begin to fly.

The cost of the freight car has increased almost as rapidly as the locomotive and the main cost is of course in the chassis. My railroad friends all object to this term, probably because it suggests our newest competitor. There is, however, a fascinating field for mechanical improvements in this connection. The principal one that comes to mind is the adaptation of removable special bodies or containers. The economies of such a system, if properly worked out, would be enormous; not only in the saving in excessive handling of lading, but the possibility of even greater saving by more constant use of chassis of the car. There are certain times of the year when there are thousands of coal cars standing idle in the country and box cars at a premium; there are other times when box cars are idle and coal cars are scarce; there are times when stock cars and refrigerators are urgently required. Isn't there a possibility of so developing and enlarging the

container idea as to be able to convert the chassis, which is the expensive part of the car, into a coal car, box car, or refrigerator car as required. It is along such lines that there is a considerable field for outside engineers to assist the railroads. The mere making of a series of bodies or open hoppers, or refrigerators, is comparatively easy. The methods of interchange and handling are comparatively complicated and enter directly into the field in which you are most interested.

I do not wish to bore you by enlarging upon this subject and going into detail figures, but I hope you will give these two problems earnest and constructive thought for your profit and ours.

We recognize our business is in its broadest aspects the greatest in the world; its uses the products of more industries and the fruit of more engineering talent than any other single business. The railroad rightfully manufactures only transportation. It buys its tools.

Most of the improvements in railroad apparatus were originated by railroad men; of necessity they were developed and manufactured in commercial plants.

The railroad man is busy moving traffic and has not the time which the manufacturer has to experiment, develop and perfect improved apparatus. We recognize that the importance of our business is greater than our pride and while in no sense lessening our own efforts we ask for and welcome assistance from any quarter that will improve our methods and the service we give.

That is the problem. The principal problem is, of course, the locomotive problem. I haven't suggested the answer. I trust it will suggest itself to you gentlemen. If the answer is the one that I believe that you think it is, and it as good as you thing it is, and the field is as open as I have said it is, I think you must confess there has been some failure on your part that it hasn't been more generally adopted. The door is wide open. There is a lot of room for electrification in various phases on the railroad. We are not electrical engineers. We are ignorant. We are not bluffing as your Chairman says. We don't know much about electricity, but we have a real problem we are struggling with very hard, and frankly, the answer isn't apparent to anybody that I have talked to who has thought about it very seriously.

Of course, if you expect to develop motive power for the railroads, and expect them to keep on paying fabulous prices for it, you must do your part towards standardizing it, towards putting it on a price basis of quantity production before you actually get to quantity production, and you cannot make a fat profit and expect the railroads to carry it and operate in red figures. We have to go to our directors, and they say "We have heard this story before." It is going to cost two or three times as much as steam engines, and where are we going to get the money? I think you will agree it is up to you.

ADDRESS BY J. E. CRAWFORD

General Manager, Norfolk and Western Railway Company

I can tell you in words of one syllable our experience on the Norfolk and Western. Our electrification problem is rather different from the problem of most of the other lines. When we first undertook electrification we were faced with the problem of handling about nine hundred cars in each direction over very heavy grades, and in very heavy tonnage, and our first thought was to investigate electrification merely from a pusher standpoint; that is, we would bring the tonnage trains up and use an electric pusher over the grade.

Our grade was two per cent, nine miles long, and a single-track tunnel at the summit with double track on each side.

After making a study we found that we could electrify from Bluefield, where we have a division yard, to Eckman, where we have an assembly yard. All of that territory which is about thirty miles, double track, was a very heavy originating territory of coal.

We put in the constant-speed locomotives, these locomotives operating at fourteen miles an hour on heavy grades and twenty-eight miles per hour where the grades were lighter and our experience with them over nine years of actual service has led us to believe that these constant-speed locomotives are suitable for that class of service.

We are frequently asked: How does the cost of electric power compare with steam? That is very difficult for us to answer. In the first place, the electric installation doesn't cover the entire division, and our figures prior to electrification, of course, cover an entire division, and they cover not only main line operation, but switching service, and all similar services.

As nearly as we can determine, however, the actual cost of operation is about eight per cent in favor of electricity. In other words, taking account of the cost of fuel, and lubrication and repair in both cases, and basing it on tractive power miles, (that is, one thousand pounds tractive per hundred miles, for example) the steam operation is about eight per cent more costly. The cost of repairing and maintaining the electric locomotives is also difficult for us to arrive at. It took us something like ninety years to develop the present day steam locomotive, and you are all familiar with machine design. You know you can't design a locomotive right from the jump as we had to, and get a perfect machine. Our experience was that the locomotive that we first designed was entirely too light, and the locomotive frame and the mechanical parts, especially, all had to be rebuilt, so that our locomotives now, in their rebuilt condition, weigh about forty thousand pounds more than they did originally. In other words, when first built they weighed about sixty-three thousand pounds on each of the eight driving axles. Now they weigh sixty-eight thousand pounds. These locomotives have the great advantage that has been touched on by Mr. Coleman, that they

are capable of much greater mileage and quicker turning. The actual starting drawbar pull of the electric locomotive shown by the dynamometer is no greater than our heavier Mallet locomotive, but the constant torque means that the pull is constant whereas with the steam locomotive it fluctuates, and in starting our tonnage trains which weigh about thirty-three hundred pounds on two per cent grade, two electric locomotives will start this train in less than two minutes and have it going at full fourteen miles per hour. They don't jerk the train, just start right away with it. The steam locomotives, on the other hand, have to take slack several times and have great trouble starting. It takes about ten minutes to get a tonnage train up to eight miles an hour.

The actual comparison from our records shows that the electric locomotives have actually made fifty per cent more mileage than Mallet locomotives in comparable service, but the reason for this is that we have eleven electric locomotives available all the time whereas eight would fulfill our requirements, and we don't have any such surplus of steam locomotives.

We estimate, roughly, that an electric locomotive should make about twice the mileage that a steam locomotive will make.

Mr. Coleman has touched on the principal problem. When an electric locomotive comes into Bluefield with a train, the regular schedule is that it is ready to leave again in forty minutes. Necessary supplies are put on and the locomotive is inspected in that time. A locomotive keeps this up continuously for about four thousand miles. This takes, ordinarily, three weeks. At the end of that time the locomotive is taken in for more careful repairs, and the average time for these heavy repairs is about two days.

Our mechanical people claim a little more for our locomotives than Mr. Coleman, and even at that, the best that we can claim is we keep a Mallet locomotive on the road fifty per cent of its time, whereas the electric locomotive is available eighty-five per cent of the time. In addition to that the increased mileage is made by increased speed in starting and on the road. The electric will make better speed on a grade.

Mr. Coleman referred to the overhead cost, and our experience is this: We bought twelve of these electric locomotives about twelve years ago, and we found that the cost of these twelve locomotives, pound per pound, was exactly twice as much as that for the steam locomotives, and of course, the tractive power will vary approximately as the weight.

During the past year or two we just contracted for four more very heavy locomotives, these weighing 875,000 pounds and with a tractive power of 140,000 pounds. The price per pound was exactly twice what we were paying for steam locomotives.

Now, if we get twice the mileage, we are right where we started, so far as the economy is concerned. So our figures don't show a very great saving by electrification so far on the basis of capital expense, but do show a very great saving on account of the quick turning, the less damage to equipment, and the greater flexibility of the machine. The actual cost of repairing during the year 1922 based on tractive power of the locomotive was thirty-seven per cent greater for steam locomotives than it was for electric locomotives so that showed a very substantial saving. Prior to that, our repair bills were away up in the air, owing to this rebuilding of the locomotives. Another factor that is very difficult to determine is the fuel saving. Of course, with us the installation is a special one of heavy service over heavy grades, and our load factor is very bad. We are apt to have very heavy instant demands on the power station, and of course, our power cost and fuel consumption is correspondingly great. I believe if we had electrification over a larger area where that factor could be equalized, of course, the fuel saving would be greater, but the best saving we can show on actual-ton mile basis, comparing the two, electric and steam, is twelve per cent. Our people estimate thirty per cent. The reason for that is that it is hard for us to tell how much fuel our locomotives would use in the same class of service as the electric locomotives, because we don't have a record of what every locomotive takes, and we do not have that separated for this particular distance. I think it is fair to say that the fuel saving under favorable circumstances would be twenty-five or thirty per cent.

Another economy which we have had with the electrical operation is regenerative braking. We have a 2.3 per cent grade about a mile in length and anybody that has tried to take a heavy thirty-three hundred ton train down such a grade with steam knows what the troubles are. Ordinarily one electric locomotive handles that train down that grade without any air application at all, and occasionally where it seems necessary to apply the air, there has never been any difficulty in working the air brakes in conjunction with the regenerative braking.

Another factor that we anticipated might give us considerable trouble was line troubles, and knocking down of lines with wrecks. We have had very much less of this trouble than we anticipated and no unusual amount of trouble in clearing the wreckage. We handle the wrecks with our regular steam wrecker that works in every other territory, and the boom of the wrecker being insulated, we have never had any trouble.

As far as reliability of service is concerned, we estimate that the delays to the traffic due to power house failures, line failures and electric locomotive failures are no greater than we would have due to engine failures in that same territory with the same number of steam locomotives doing the work, and in addition to that our failures from damage to equipment, brake shoes, pulling draw bars and so on, is very much less.

Our conclusions after nine years of electrification is that our operation as a direct operation doesn't show a

great economy except that the economy is in the increased capacity of the line, the increased speed and decreased turning time. We will continue to extend our electrification when our line facilities become inadequate, and when our steam power also becomes inadequate, because we can't afford to scrap steam locomotives and buy electric locomotives just to be scrapping something.

We now have under construction twenty miles of additional electrification, and I think before very long we will extend it over the entire division.

Discussion

Chairman N. W. Storer: We, of course, have known for many years that the steam locomotives are not what they ought to be but we have heard recently of wonderful improvements in the steam locomotive. We find that after the example was set for them on the Milwaukee Railway with electric locomotives, where entire electrified zones of 440 miles were covered without changing locomotives, they have had nerve enough to try that with steam locomotives, and they are getting away with it. Some reports come in that very much greater mileage than 440 has been made by steam locomotives.

Now, doesn't that mean that these improvements which Mr. Coleman has spoken of are being better taken care of on some of those western roads?

We hear also of very long trains being handled, 100 to 120, maybe 150 cars; we hear of very heavy tonnages, maybe 9000 tons or more on one train, on the Virginian. We know that these late locomotives are going up to 75,000 pounds load per driving axle. We know that there is considerable question as to what the maximum tractive effort is going to be; what the draw bars can stand; what is economical for them to stand, and we want to know further about what is the most economical speed.

N. D. Ballantine, Assistant to Vice-President, Seaboard Air Line Railway Company, Baltimore: I have been very much interested in the development of the electric locomotive just for personal information and have been impressed with the apparent lack of correlated information with respect to the relative merits of electricity versus steam. One will touch on a certain phase of it, another on another phase, and so on, but I have not yet seen a fully correlated comparison, one which takes into consideration the difference in the investment, not only on the motive power itself, but on the railroad as a whole, and its ability to operate as a whole, the utilization of the motive power, and the ability to do a certain thing within a limited time.

Ordinarily, railroads are improved to take care of a peak load and it is understood, of course, that you must provide sufficient motive power and other facilities to meet that situation.

Now, what you can get out of a locomotive or out of facilities the year round isn't the real answer, to my mind. It is what you can get out of it during the period of peak demand. The real test is the amount of capital invested in road and equipment, to meet a given transportation problem.

When you speak of speed, I assume you refer to fourteen miles an hour, up maximum grades. I suspect that is a higher speed than you obtain with your steam locomotives with the same tonnage.

Mr. Crawford: I mentioned that difference. We figure steam eight miles, and electric fourteen.

Mr. Ballantine: There is a 75 per cent increase. That is a great factor in increasing the miles per car per day during peak demands, and if you can secure the miles per car per day during the peak demands, then you have very much less capital necessary to invest to lie idle for the other nine months or so, when your equipment is not needed.

With regard to the utilization of the motive power, I made some studies a number of years ago on that subject, and found that during the period of maximum demand, there was about two hours and fifty minutes actual motion or earning power of the freight locomotive. That is, it may be between terminals, but it is standing still part of the time between terminals. On single-track railroads with dense traffic, that is an important factor. I know there has been a very substantial improvement in the steam locomotive in the last few years, and I know that some of the western roads, one with which I was formerly connected, is making six and seven hundred miles, and I read not long ago that one railroad is making a passenger run from El Paso to Los Angeles of about eight hundred miles, and doing it regularly.

In order to do that, the point that your Chairman mentioned a while ago about having your power in first class condition is one of the most essential factors. The Southern Pacific is using oil which is a vital factor in increasing the length of runs for motive power.

Chairman Storer: We want to go the limit when we talk electrification, and we have got to know or have some idea at any rate—we can't expect to know absolutely what is going to happen—what the steam railroad man is looking forward to. We know that the increasing traffic every year is going more and more to tax their resources. How do they expect to handle this? Are they going to do it with steam locomotives? If so, what will be the size of the trains? What is an economical train unit? Is it going to be 100 cars, or 150 cars or 200 cars? Is it less than a hundred cars? What is the draw bar going to be designed for? We know that when you go up to a very heavy draw-bar pull, it adds very materially to the weight of this "chassis," which word the steam railroad man dislikes so much. We know it is bound to add weight to that when you have a locomotive capable of developing 140,000 or 150,000 pounds pull at the head of a train; it means an enormous strain on the draw bar.

That takes metal in those cars; it takes metal all the way through. It isn't handling traffic the way they do in Europe, where they have a maximum allowable stress on couplings—we wouldn't call them draw bars in this country—of twenty tons. That is the maximum they can go to. It is a limitation which they have accepted. A few years ago it was about half that. On many roads it is very much under twenty tons now. They make it up by handling their light trains at higher speeds.

I would like to have Mr. Coleman and Mr. Crawford tell us what they are looking forward to in the way of draw-bar pulls, speeds, length of trains, and so on. How would they like to handle a traffic of three times what they have now?

Mr. Coleman: What are the limits? The sky is the limit. What would we like to do? There is nothing we would not like to do. It isn't a question of what is the limit. It is a question of how far we can go.

We have a plant today that is limited in a hundred different directions: weight of bridges, length of passing tracks, length of yard tracks, and so on.

If you want us to set up a lot of technical, arbitrary limits, which would evolve for you a practically perfect railroad, we would scrap our railroads, and build new ones. That is impossible. We have our railroads today. The average railroads are not so fortunate as some of the coal-carrying roads with short mileage. They can put in relatively heavy bridges and raise their axle loads. Some of the modern lines have a maximum load of sixty thousand tons. Many run higher, but it decreases the life of the bridge. If you are going to have heavier loads, it means not only greater wear on bridges, but wiping out the bridges and putting in others.

What is the longest possible train? The average main line railroad today has, roughly, about a hundred-car trains. Some

go further. If you are going to build your ideal locomotive and haul longer trains, you must have new passing tracks, new bridges, new classifications. We can't do it. You have to take the average railroad as it stands today.

It seems to me if the electrical engineer is interested in putting electric motive power on the railroads, it ought to have been worked out. You can hire men to do that sort of thing for a couple of hundred dollars a month to tell you what those limits are. What you have to do is develop an electric locomotive that will fit into the railroad and build it.

What is the drawbar capacity? I don't know. Nobody does. You talk about your western railroads being so much more economical and running these long passenger trains. It is the freights that we are talking about. Nobody is running freight trains seven or eight hundred miles with one steam engine.

There is one railroad in the East that with a steam locomotive pulled ten thousand tons in one train not long ago, pulled it seven hundred miles, took twenty-four hours to do it. I am not going to tell you how long it took to fix up the engine when it came back.

We are not limited to what we can put on the draw bars, but there are these limits: bridges, sidings, weight of rail, etc.

He wants to know how fast is an economical speed. According to the average railroad operating office, the most economical speed is just as fast as you can safely turn the wheels around. The average freight car can run fifty miles an hour without injury to itself. If conditions permitted us to move freight trains an average speed of fifty miles an hour, we would be all right.

We are seeking on our railroad to move up the speed except on grades. Naturally ten miles is about the limit you can expect, on the ruling grade which is less than five per cent of the miles. On the ninety-five per cent, we want our trains to run forty miles an hour. That is what we want electric locomitives to do. If we could change the block signals, we might run sixty, but the modern steam locomotive wouldn't stand sixty. It would shake itself to pieces. That is why we stop at forty.

As I said, the sky is the limit, theoretically. The practical limit is the present practise on the average railroad.

There is one question I am going to enter upon delicately. I can't understand my brother railroad officer here today. I sat and listened and jotted down quite a few figures he gave on the savings made with electric power. Then he wound up by saying he couldn't see that there was sufficient economy in the electric power to warrant its further extension to the railroad until they needed to increase the capacity.

I don't want to be critical. I am seeking information, but I am rather of the opinion that the difficulty is not so much that he can't show an economy, but it would bring in the necessary cost of scrapping a lot of steam power. You can't electrify piecemeal under present conditions. To electrify a whole division means rather a large initial expense.

I figured on two or three railroads the other day and got some figures from some of our electric friends. I find in addition to the cost of the power, it takes in addition from ninety to a hundred per cent of the cost of the power, for the subsidiary costs, such as trolleys and substations and things of that kind, not counting power stations. Say you took a division that required fifty engines, costing $150,000 each: you would have to double that amount. That is a pretty big investment for the railroad to go into, at the same time scrapping a lot of steam equipment. The only way a road can do that is by moving that steam power over as an extra power on other divisions and this is economical only when the extra power is needed on the other divisions. There is a need for locomotives that can come in one or two at a time, and supplant the steam engines gradually, until eventually there results a complete electric unit. Your are now confined to the very large railroads unless Mr. Cumming's consolidation goes through, and you can afford to consume the extra power. There is no market for the secondhand locomotive today. In the old days no superintendent could lend a locomotive to another division without having it go into the shop before he could use it again. I don't know that anyvody wants any secondhand stuff today.

Chairman Storer: Mr. Crawford touched on the question of fuel economy. Some of our people have been claiming that we could make a saving of about two-thirds of the coal.

Now, I don't think that even Mr. Coleman or Mr. Crawford will question that some of the roads could make that much saving, but of course the steam locomotives have been brought along of late years. We had a paper presented before the New York Railroad Club recently on the fifty per cent cut-off steam engine, claimed to produce an indicated horsepower-hour with two pounds of coal. That is bringing in new evidence, and of course, the electrical people wouldn't make a claim that we can save two-thirds of that two pounds. That would be rather excessive, but between you and me, not talking for electrification at all, I don't believe we are going to run an average over the road with a steam locomotive of such a rate of fuel consumption. They do that on a stand test, but the probabilities are that the efficiency of that steam locomotive will decrease as its life goes on, and with various kinds of loads and grades, and with various kinds of firemen, the probabilities are that the efficiency will be considerably less than that.

Mr. Brenner: There is one problem we haven't considered. There is no doubt but that by means of the central station we will save in fuel, but at the present time we are limited to the single-phase motor. We are also limited in our voltage.

A. H. Babcock: In what I shall say today, I wish to speak from the point of view of an operating railroad official, not an electrical engineer. I can't speak at all with reference to any of the Eastern problems because in such matters I have had no experience, but for the last twenty years I have been studying large similar problems in the West.

I propose to speak directly to the point Chairman Storer raised when he asked what the steam railroad man is looking forward to in electrification, and I propose also to answer Mr. Crawford when he says that as far as he can see, it is not a question of economy in operation so much as a disinclination to scrap steam equipment.

We shall take up the last point first. As far as scrapping steam equipment is concerned, Mr. Crawford's question is completely answered by the simple statement that in one year the Southern Pacific Company buys so many steam locomotives that there would be no necessity to scrap this sort of motive power from any one of its divisions that might be electrified; all of the power would be transferred to other divisions and used with equal efficiency. Therefore, electrification would mean merely that part of the money formerly spent for steam locomotives would be spent for electric locomotives.

Speaking directly now on the question of economy: In order that those of you who have not been over our Western mountain railways, may realize the situation, I will outline briefly the condition on one of our Divisions. Picture a district 140 miles between engine terminals, which is very approximately the distance between New York and Albany; the east terminal 4300 ft. above the west terminal, with a 7000-ft. mountain in between, located 86 miles from the west terminal; on the west slope an average 1.51 per cent grade, with a maximum of 2.6 per cent., instead of the water grade between Albany and New York; 26 per cent of the track curved between 8 deg. and 10 deg. 30 min. The line is all either double or second-track, except 41 miles over the Summit, which is single track. Of these 41 miles, 32 are covered with snowsheds, of which 23 in the winter time, when the snows are deep, constitute a continuous tunnel, the sheds being completely covered. This should be contrasted with the three and four tracks between Albany and New York.

Over that single track—through the neck of that bottle—under maximum crop conditions in the early fall, there has been operated a train movement every 23 minutes.

The conditions then, in general, closely approximate the Norfolk & Western Elkhorn grade, except that for that road the heavy tonnage is in one direction and downhill.

If there can be found in this country any more ideal location for an electrified line, according to the proponents of electrification, I have yet to hear of it. Since 1904 this situation has been studied repeatedly both by the large electrical manufacturing companies, (whose engineers have gone on the ground and have been furnished all information at the disposal of this Company that would cast light on the subject), and by our own officials, assisted in one case by Frank J. Sprague. Not one report has yet been made in which could be shown a reduced ton-mile cost of hauling freight, when all charges of every nature were properly included. This same general statement is equally true of the Tehachapi Pass on the south, and of the Siskiyou Pass on the north.

In spite of these facts, the public is being educated to the point of view that the Southern Pacific Company is backward in making large expenditures on which economy of operation is promised by the manufacturers. There will be many cases where electrification is warranted by reason of terminal congestion, or otherwise impossible tunnel situations, but after twenty consecutive years spent in the study of these problems, I have been driven to the opinion that the one essential convincing argument that the advocates of electrification in general could advance to those responsible for the economic operation of the steam railroads in this country, is to demonstrate beyond a reasonable doubt that there exists in this country today a single case of profitable electrification, when all charges of every nature are included. I am compelled to the belief that there is no such property, for the simple reason that if there were one, that fact would have been shouted from the house tops.

W. S. Murray: Mr. Babcock asks us to show him one division in the United States that can show a profit. There is no such thing, gentlemen, as a one hundred per cent electrification in this country, not one, so will you tell me how we can show you something that we have not got?

Let's take the New Haven electrification. Maybe that has a service upon it, freight, passenger and switching, which may come more nearly to the point Mr. Babcock has made. I can say to you, not in confidence, but in fact, having been on that electrification from 1905 to 1917, in charge of electrical construction and the electrical features of operation, that just at the time when we desired to embrace such an opportunity as would permit us to answer Mr. Babcock's question, we were robbed of the very cream of result which would have obtained because of the unfortunate financial conditions in which the New Haven became involved. If a sufficient number of engines to fill out that one hundred per cent schedule had been bought I can assure you beyond doubt that every one of those final engines would have earned thirty per cent upon its own investment.

Take the Milwaukee: A tonnage of three or four freight trains a day over three divisions of 220 miles each, with a steam gap between two of them, what sort of an opportunity does this afford to show a profit? Take the Norfolk and Western. Mr. Crawford tells us that this road is only in partial operation.

Now, I will cite an instance of proposed railway electrification where within two or three hundred miles of here, there are two divisions end-on which are having translated over them forty-three thousand tons in one direction and fifty-three thousand in another daily, over changing grades, varying from 0.8 per cent on one to 1 per cent on another, these grades not being over nine miles long.

I have placed upon that proposed electrification a very large overhead charge for line equipment in duplicate. Although it is double-track system, to insure service, I have applied pretty nearly every dollar you can think of in order that power might be supplied adequately, reliably and cheaply, and I can say that unless my experience for the last twenty-five years in railway construction and operation counts for nothing, the return on electrical operation of those two divisions will be between fifteen and twenty per cent.

I believe that the most important requirement of railway electrification and the one which will accelerate its application to the maximum is that the railroads be relieved of capital charges against power stations and the electric motive-power equipment.

The question I would like to ask Mr. Coleman is: Is there anything in the railroad man's mind against the supply of power to the railroads by the electric utilities?

I was much interested to hear from Mr. Crawford that the electric engine was available for service 85 per cent of the hours of the year, but much surprised by Mr. Coleman saying that the steam locomotive was good for 45 per cent of the time. I had rather thought that the steam engine was only good on the average for about 2500 hours of the 8760. If it is 45 per cent, that puts it over 3500 hours. I would like very much to get a little more information as to that.

If we can finance the railroads by issuing equipment trust bonds for their motive equipment and if the electrical utilities can supply the power, this leaves only the railroads to construct their contact lines and finally, if the electrical investment will return 15 per cent while track capacity through electrification is increased two-fold, under these conditions, is there any reason why a railroad should not electrify?

Chairman Storer: It isn't a question of electrification we are after today. We want to know what the railroad problem is. It is simply one of motive power, or is it something bigger? How is the increased capacity going to be secured? If Mr. Coleman speaks truly, why, the railroads must go ahead handling the freight with their present limitations in bridges, which means axle loading, and we can gain somewhat by increasing the speed.

If forty miles an hour is a reasonable figure, we don't ask for absolute limits. The blue dome of Heaven may be the limit, but I don't know what that blue dome is.

I would like to have a little statement from Mr. Ballantine as to what he considers is a peak load. I have heard that question of peak load on the steam railroad for twenty years, and I have yet to hear anybody put up a real concrete case of what they want to do with the peak-load condition. I want to tell you privately if we get that peak-load condition definitely specified, we can handle it. I don't care whether you use steam or electricity, it can be handled.

Mr. Ballantine: The railroads of the United States during 1923 have had the most wonderful situation with respect to peak load sustained throughout the year that they have had in their history. Ordinarily, prior to the war, the railroads had what we called in railroad parlance, the peak load in the months of September, October and November. Those were the three peak loads for the carriers. What we mean by peak loads is the greatest volume of traffic necessary to move in a given direction. Ordinarily the traffic of this country is moving one hundred loaded car miles east and fifty loaded car miles west, because the population lives in the East, and the traffic originates in the West. In 1923, the net revenue ton-miles did not vary more than 13.7 per cent from the low month to the highest month.

The nearest approximation to that with respect to level of traffic for the period for which we have records is 26 per cent variation, and that varies up to as high as 55 per cent variation, which is expensive operation. When a plant has capacity for one hundred units and runs on fifty one month and seventy-five the next, and 110 the next, and you attempt to move during the fall

months what should have been moved throughout the year it can't be done without enormously increasing overhead. You have to provide for uniform traffic or higher freight rates because the additional motive power and equipment necessary to take care of it has to lie idle from eight to ten months throughout the year.

Chairman Storer: I just want to make this one statement, that I have sometimes heared this peak load referred to as being a load that is encountered in removing congestion on a line following a wreck or something similar. I think this question of handling the varying peak loads throughout the year is easy. That is merely a question of motive power, and the necessary power supply to be available at the time you have that peak load.

Now, on the New Haven road, for instance, you know once a year there is quite a little traffic that goes down toward New Haven. They have a football game there that takes about all the rolling stock on the road to get the people down there in time for that game, and away from it afterwards.

It is my understanding that in every case where they have had such conditions they have had every electric locomotive available for service, and they have never fallen down on it. That is the last I heard. You can count on practically one hundred per cent motive power ready for such extraordinary loads.

That, of course, means that you can take care of peak loads. It might not last throughout the year, but it simply means that you have an ordinary surplus for the worst cases of peak load or possibly may have to have 10 per cent more locomotives than are necessary for the regular service on the road.

William Elmer: Couplers have been designed and re-designed, and again designed and redesigned over a period of many years, and when you consider that there are over two million freight care in the country, it is not likely the couplers can do much more developing without inordinate expense. The freight-car coupler which is now used by the majority of the roads has been created and passed upon by the Master Car Builders Association, and is known as the Standard Type D Coupler. Those are good for a draw-bar pull of about 400,000 lb. without failure. You must take some factor of safety to provide for the jerking which takes place with the heavy freight trains and on the special coal-carrying roads.

We also design the under-frame, the draft gear and the sill for 400,000 lb. so I think for many years there will not be very much increase in the strength of the car underframe or in the coupling and draft-gear apparatus. That is one point from which we can start.

The subject of bridges has been mentioned, and that will bear comparison with the draft gear. If the axles are good for 100,000 lb. we might say the draft gear is good for a breaking load of 400,000 lb. I don't think we will see much change in that for many years.

The weight of the train has been mentioned. Some of the coal-carrying roads have gone up to great train weights. That traffic is carried usually in special cars. The 50-ton car is considered the usual coal-carrying vehicle. If you will put a lot of those cars together and get a long train, you will have difficulty in road operation.

Our division, of which I happen to be the superintendent, running between Harrisburg and Altoona, has been running for a good many years one-hundred car trains as standard loaded trains.

In days gone by the cars were less than 50-ton capacity. Now we have a good many 70-ton cars in the train. If you get the newer cars, the 70-ton cars, something like 45 ft. in coupled length, and you have a hundred cars in the train, you find it is a long distance from the cabin to the locomotive and return, and you can get a train so long that the train crew is not able to give you economical service. So I think we might put our feet on the ground and say something that would be more convenient. When you get 4500 ft. of cars, it is a long walk, and if there is trouble at the front end and the conductor is in the rear, and the locomotive stops with the pilot close to the signal bridge, it is a long operation, and you can't expect to get much speed.

So I think we can say a hundred cars, roughly, will be the maximum train in a good, sensible railroad operation. We are doing it day in and day out, and I have no hesitation in saying it is a perfectly practical thing. I have no doubt some railroads can operate 125 and 150-car trains, but I believe the conditions under which they operate are especially favorable.

Our division operates seventy-five passenger trains a day on a four-track railroad, and handles from twenty-five to forty-five freight trains in each direction. Not all those trains, of course, are of the length I have just described. We have the preference freight trains, fast freight trains, or trains that carry from thirty to fifty or sixty cars, but the slow freight trains on which we depend for a great deal of our revenue on my division are made up of those hundred-car units. That is the direction of our loaded traffic, which happens to be coal, which is the largest portion of our tonnage, which is naturally moving eastward. In the opposite direction the trains are made in 115-car units. Those, in the majority of cases, are empty cars, and the drawbar pull on level track isn't nearly as great to move the empty trains as the loaded trains in the eastern direction.

The speed has been mentioned. One gentleman said if he could run freight trains at fifty miles an hour he would do it. A sustained speed of fifty miles an hour for the freight trains, I don't think is practical in this country with the loads we have. I don't say some of the divisions in other parts of the country with lighter trains may not be able to get away with fifty miles an hour, but with these coal-car trains with marked capacities of 140,000 lb., with the ten per cent overload which is usually given, fifty miles an hour is not a profitable mileage. In other words, we would have so much trouble with hot boxes, that I don't believe we would be able to handle as much traffic as with a more moderate speed.

There is something to be said from the Pennsylvania standpoint about speeds. You remember the arrangement with the locomotive and train-service men requires a speed of twelve and a half miles an hour. Their terms are one hundred miles a day, eight hours, which is twelve and a half miles an hour. That, in order to avoid overtime must include all the time when the crew is on duty, so if it takes two hours to assemble a train and get out of the yard and an hour to put the train away after reaching destination, there is three hours. If you have a crew that gives you eight hours a day, that is five hours left for moving the train one hundred miles. That is twenty miles an hour which is not a very economical speed. Our division is operating without an excessive amount of overtime. We try to have the overtime at a minimum. It must be paid for at the rate of time and a half for overtime. If we can keep our overtime at 12½ per cent, we think we have a fairly economical operation.

So in the case of high speeds you will have to pay (unless some miracle from Heaven comes about) for the time that they are allowed to make the mileage involved. If you can make the run and gather the train together and dispose of it, place the engine and the cabin away, and do all that in five hours, you will still have to pay for eight hours' time on a one-hundred-mile division. Those are some of the considerations of the Pennsylvania. The wages under the present rules have to be taken into consideration.

The amount of traffic that can be handled over a division depends on many factors. On our four-track railroad, we can dispatch a train from the yard every twenty minutes. That means with our hundred-car trains eastward, three hundred cars an hour, or 7200 cars a day, if we keep that up regularly. We have never been called on to do it because the connecting division can't deliver to or receive from our division such a traffic. But with our present four-track division, I am sure we could handle 7200 cars a day in each direction and keep the passenger trains

moving, or allow a 10 or 20 per cent increase of our passenger-train movement without requiring any additional facilities.

Some reference was made to the mileage that the electric and and steam locomotives make. Every month the records of our freight locomotives show some having made five thousand miles in the month; about 25 per cent making over four thousand miles a month; and over 50 per cent making over three thousand miles a month. Of course, there are always engines in the shops, some of them for an entire month, some for more than a month—new fire boxes required, etc.—but when the division can show a record of more than 50 per cent of its engines making more than three thousand miles a month, I think the performance of the steam locomotive can be considered as fairly good.

I have no means of knowing at present what mileage the electric locomotives can make in sustained effort year after year. The Norfolk and Western condition was touched on but a great deal of rebuilding was necessary so they haven't had a fair chance to show what they can do when the locomotives are all brought to the standard which is required.

Our passenger locomotives show a number of engines making over ten thousand miles every month, and about 50 per cent will make more than five thousand miles a month.

An engine which has been put through the shop and is in good condition and keeps on working day in and day out will show mileage of about 160 miles in freight service on the days it works. We are fortunate on our division in having 130 miles of railroad, and naturally should show more mileage than the New York Division for instance, which has not more than ninety miles.

The turning time of the engine being practically constant, the longer the division the better the mileage will be, so we are very favorably situated in our opportunity to show a high mileage.

The question was also mentioned as to mileage which could be obtained for locomotives in general. The highest peak which the railroads ever had before this past year was in October, 1920, and the statistics kept by the Interstate Commerce Commission on the returns made by the railroads showed an average of fifty-five miles per day for all the freight locomotives in the United States.

During the period of 1923, mentioned by one of the speakers, the maximum business the railroads were called upon to handle was practically a million cars a week, loaded with freight. The best they were able to do was in the month of September when the Interstate Commerce Commisison statistics showed 55 or 56 miles per locomotive per day. If the engines are moved at the rate of ten miles an hour when moving, that means we have 5.6 hours per day when the engines are moving.

Chairman Storer: Will you explain to us the necessity for the frequent classification yards, other than from the limitations of the locomotive? Is it necessary to have the yards on these short divisions of 100, 130 or 140 miles?

Mr. Elmer: No, I should not say it was necessary. The Pittsburgh Division to the west of us is an originating district for coal. The line starts from Altoona, takes the empties to the mines, where the coal is gathered up, brought in loaded trains into Altoona, and naturally the coal must be dispatched to various destinations. A man in Philadelphia might order coal from a mine in a certain district; they may have five cars a day of different priced coal for another group of customers. When those cars are gathered together, naturally there can be no order in which they are brought in, so they must be classified and all the cars destined, say, to Baltimore grouped together, and these, also, separated between export coal and the various domestic coals. Dealers' cars for the New York District must be separated and segregated again. Those for shipment on barges are placed on one track and those for power stations on another track, and so on, in the classification yard. Then those cars are ready for the distant places. When enough tonnage is accumulated a train goes to Baltimore, and then another to Philadelphia, and then another to Jersey City, and to Harrisburg, etc.; and of course, the coal for the railroad itself is interspersed in considerable quantity. So the first dispatch yard must have a lot of classifications. After trains are first made up, it is every one's desire to keep them moving without further classification, in order not to delay too long. Sometimes it may be two or three days before a certain classification is ready.

Those trains must be sent out with three or four classifications in some of them, then to Harrisburg, and again be broken up, some of the coal going to the Philadelphia and Reading for the customers they have in the eastern part of Pennsylvania not reached by our railroad, although the coal mines from which they buy their coal are located on our railroad. Some of it would then be subdivided again and go to different territories in New Jersey, some to the southern part of New Jersey and some to the northern part. So I don't think we can ever have a coal train made up solid at any one mine and go to any single destination except at a very large operation where some tremendous power plants in Jersey City might want a train load of coal a day. That is not a very frequency possibility, so the classification yards are necessary evils to railroad operation.

They may be unduly close together, but I can only speak from our own necessities. Our Altoona yard which gathers the coal is at the end of the division. Then coming into Harrisburg, we have a branch in the lines that continues east and those that go south, and that seems to be another logical point. From Harrisburg we have a division into the Philadelphia district, which requires a number of different kinds of trains for the yards, for the export and local delivery in the Philadelphia district. Of course, the other large leg of the operation goes toward New York and feeds the country in New Jersey and New York; and still again there is a leg for export and local consumption in the seaboard of New York.

I think Mr. Murray may have unintentionally said something which he did not mean, but my recollection is that the statement was made that there was a difference of 8 per cent in favor of the operation by electric locomotives over steam on the Norfolk and Western. I thought I heard Mr. Murray say something that indicated 8 per cent return on the investment. I understood that there was an 8 per cent saving only on the operation.

Mr. Crawford: On the question that seems to have been brought up about the operating cost of electric locomotives as compared with steam, our experience indicates this: That the cost based on the tractive power of electric locomotives, including the power cost and the direct cost of operating, is about eight per cent less than we estimate the cost of steam doing the same work. That merely means the direct cost of fuel, lubricants, repairs, etc., of the locomotives. It does not include any indirect saving or anything for capital account, and it doesn't include anything for a saving which we might have made by increased capacity of line.

Our problem is one of getting very heavy tonnage and a very large number of cars over a congested district, and our experience leads us to believe that the economy in electrification now is in enabling us to postpone heavy expenditures for additional tracks and additional tunnels, additional yards, etc., by reason of electrification rather than by any direct operating saving.

Mr. Coleman: I think Mr. Elmer's figures show the problem that we are up against, fifty-five miles a day for locomotives for this country. At ten miles per hour that gives $5\frac{1}{2}$ hours per day which is less than twenty-five per cent in availability.

During Federal control the only time we had figures for the country as a whole was the month of October, 1918, when we were all doing all we could to move traffic the month before the Armistice was signed. The actual average for the through freight locomotives, eliminating passenger and switch engines for the United States as a whole, the hours available for service was 36.76 per cent. Some roads ran higher, and some lower. I think the situation is considerably better today, but I think that for any standard main-line railroad, taking all its power into consideration, it will still run under 45 per cent.

Lightning Arrester Experience in California

Particularly as Regards the Southern California Edison Company's System

BY EDWIN R. STAUFFACHER
Associate, A. I. E. E.
Southern California Edison Co.

THE southern portion of the Pacific Coast is comparatively free from lightning disturbances and the number of such disturbances, as compared with the number of lightning storms in other sections of the United States, is quite small. However, the expansion of the high voltage transmission network with the installation of many additional substations and further expansion of distribution systems has made necessary the use of some form of protection against transient high voltages throughout the system of the Southern California Edison Company.

To give an indication of the frequency of lightning storms and roughly of their geographic location, as well as their location with respect to the transmission net work, the map herewith reproduced shows lightning disturbances on this system during the years 1920, 1921, 1922, and 1923. Each storm is indicated by a black

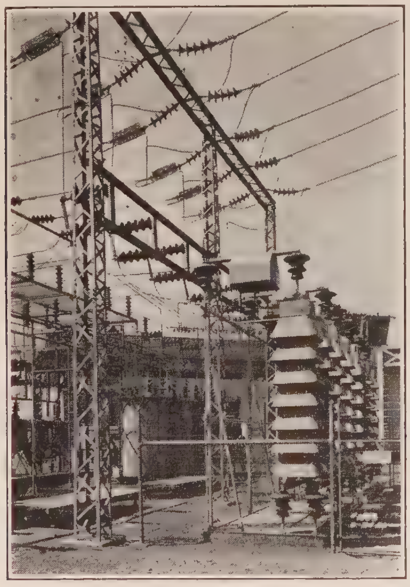


FIG. 1—OXIDE FILM ARRESTER AS APPLIED TO 60-KV. LINES AT MEDIUM SIZED SUBSTATIONS—KATELLA SUBSTATION

dot, with only one dot indicated if several disturbances occurred the same day. In addition to this, the tabulated data gives in greater detail the location of lightning disturbances. During these last few years there have been quite a number of interruptions due to lightning on this system. Previous to 1920 lightning disturbances did not constitute a large proportion of the various causes of minor service interruptions, yet during the latter four years lightning disturbances have become quite a factor in the cause of interruptions. The application of relay protective devices has, however, usually confined the disturbances to circuits affected by the lightning discharge. Whether this increased number of interruptions is due to more lightning, or whether it is due to the expansion and greater com-

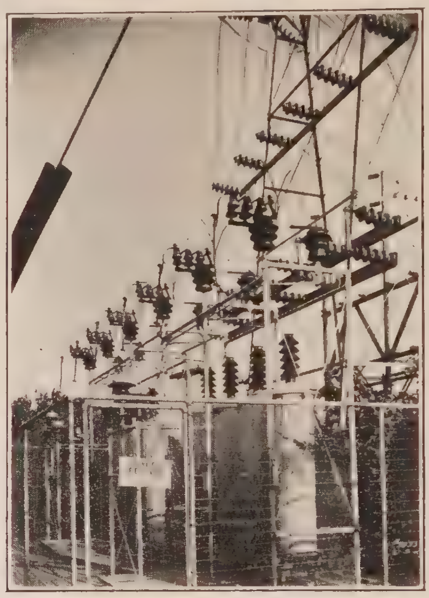
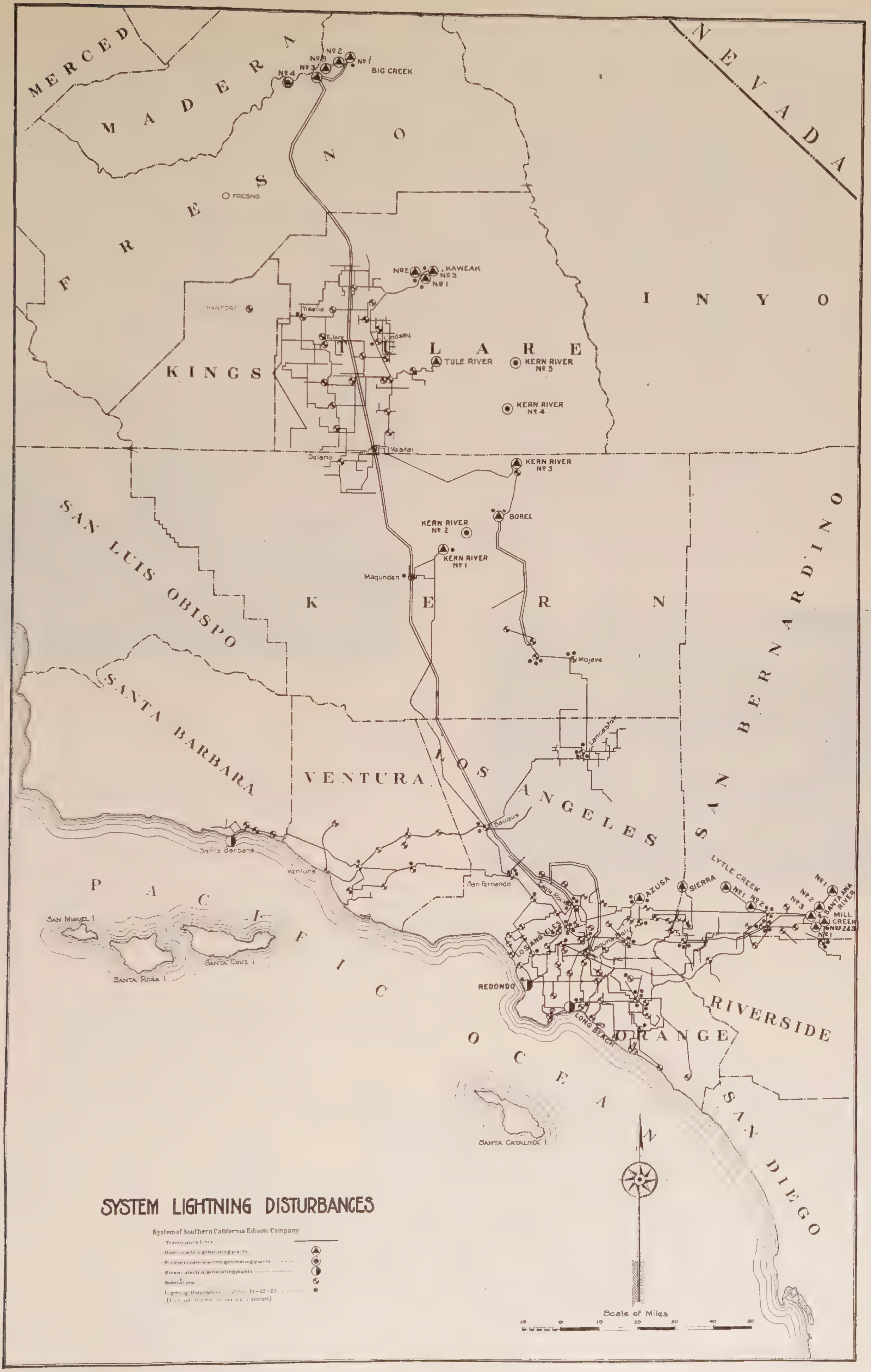


FIG. 2—TYPICAL OLDER DESIGN ALUMINUM CELL LIGHTNING ARRESTER SET-UP AT TRANSMISSION SUBSTATION ON 60-KV. LINES—CASTAIC SUBSTATION

plexity of the 60-kv. network is hard to determine without considerable research into the climate of the Pacific Coast as regards this particular feature. A thunderstorm map issued by the United States Government, which covers a period of ten years between the years of 1910 and 1920, indicates that very little lightning took place during that period on the Pacific Coast. It is definitely known, however, that the transmission system has expanded and probably this is the greatest factor in the cause of interruptions due to lightning disturbances on the system.

In the past, the general practise in the use of lightning arresters on the system of the Southern California Edison Company was to install an electrolytic aluminum cell arrester on a bus of the larger and more important generating plants and substations. At the time

Presented at the Spring Convention of the A. I. E. E., Birmingham, Ala., April 7-10, 1924.


SYSTEM LIGHTNING DISTURBANCES
System of Southern California Edison Company
Steam electric generating plants
MERCED
MADERA
FRESNO
NEVADA
INYO
TULARE
KINGS
KERN
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
ORANGE
SAN DIEGO
PACIFIC OCEAN
BIG CREEK
No 1
No 2
No 3
No 4
Fresno
Hanford
KAWEAH
Visalia
Tulare
Lindsay
TULE RIVER
KERN RIVER No 5
KERN RIVER No 4
KERN RIVER No 3
KERN RIVER No 2
KERN RIVER No 1
Delano
Vestal
BOREL
Magunden
Mojave
Lancaster
Saugus
San Fernando
Santa Barbara
Ventura
San Miguel I
Santa Rosa I
Santa Cruz I
Santa Catalina I
REDONDO
LONG BEACH
AZUSA
SIERRA
LYTLE CREEK
SANTA ANA RIVER
MILL CREEK
N
Scale of Miles
10 0 10 20 30 40 50

of lightning disturbances, it was shown that the installation on the bus alone was not always a satisfactory means of protection. However, the disturbances were of such comparatively rare occurrence, it was thought that the installation of an expensive lightning arrester on each overhead line radiating from the generating plant or substation was not justified. But since that time this decision has been modified and during the past few years it has been the practise to install arresters on each of the overhead lines radiating from the substation or generating plant and not to install an arrester on the bus. The cost of equipping all of the overhead lines with an arrester is an appreciable factor in the cost of a substation and has necessitated the use of arresters of a less expensive type than the electrolytic aluminum-cell type. The higher-voltage lines are in general being equipped with the dry chemical type, such as the oxide film arrester or the glow discharge type of arrester, such as the auto-valve. In some cases the graded resistance type is used. The lower-voltage lines are, in the case of the larger substations, being protected by means of similar equipment. In the majority of cases, however, the lower-voltage lines have been protected by some form of horn-gap arrester, such as the graded resistance

Fig. 3—Typical Early Installation of Aluminum Cell Lightning Arresters at Small Hydroelectric Plant—Santa Ana River No. 1

type or some form of multi-chamber, a compression chamber, or the glow-discharge type.

During the past few years experience has shown that disastrous fires may result from the explosion of an aluminum-cell electrolytic arrester. In the case of a severe explosion, burning oil would be thrown in all directions, with the result, that a fire could be readily communicated to the remaining portion of the substation. This hazard led to the policy of removing all the arresters of this type from the interior of the substation or generating plants, and in addition, all arresters of this type are being removed from the roofs of generating plants and substations. It is only under very exceptional cases that even the dry type of arrester is installed inside of a building. The present policy is to use arresters which do not constitute a fire hazard and locate them outside of the building. In case some slight fire might result, due to the arrester attempting to handle a greater discharge current than that for which it was designed, the fire will not then be communicated to the remaining portions of the building.

No arresters are at present installed on the 220-kv. transmission lines. All 150-kv. arresters have been removed from their position on the 150-kv. bus of the Big Creek generating plants and substations. With only one exception, the removing of the 150-kv. arresters was dictated by the fact that it was located inside of a building where it was thought it constituted an

Fig. 4—Typical Graded Resistance Arrester Set-Up at Small Isolated 11-Kv. Distribution Station—Laguna Beach Substation

unnecessary fire hazard. The practise is now to install arresters on all of the 60-kv., 30-kv., 15-kv., 11-kv., 4-kv. and 2.3-kv. lines. Experience has indicated that the protective value of an arrester increases as the lower voltages are approached. This opinion, however, is based only on a general survey of the lightning disturbances on the various lines segregated as to voltage, as shown by the following table.

TROUBLES DEFINITELY KNOWN TO BE DUE TO LIGHTNING
1923

	Potential of Current Affected by Lightning					
Month	10 kv.	15 kv.	30 kv.	60 kv.	150 kv.	220 kv.
January						
February						
March						
April	15	16	2	4	1	
May						
June						
July						
August	2	2		1		
September	16	4		5		
October	51	11	1	2		
November	12	6	3	2		
December	2		2			
Total	98	39	8	14	1	0

Fewer troubles are indicated on the 30-kv. circuits than on the 60-kv., but this is due to the fact that the 30-kv. lines constitute a very much less proportion of the total overhead lines than do the 60-kv. lines. No data covering lightning disturbances on 2.2-kv. lines were available.

LIGHTNING DISTURBANCES ON SYSTEM OF SOUTHERN CALIFORNIA EDISON COMPANY

1920

Date	Time	Location
2-3 -20	3:26 P.M.	Chino
5-20-20	10:08 P.M.	Katella
5-20-20	10:15 P.M.	Santa Anna
	&	
	10:42 P.M.	
5-20-20	10:20½ P.M.	Katella
5-20-20	10:20½ P.M.	Los Alamitos
	10:27 P.M.	
	10:29 P.M.	
	10:30 P.M.	
5-21-20	2:05½ A.M.	Puente
5-21-20	2:37 A.M.	Puente
	2:37½ A.M.	
	3:53 A.M.	
5-21-20	4:10½ A.M.	Los Alamitos
5-21-20	4:24½ A.M.	Katella
5-21-20	5:10 A.M.	Fullerton
7-15-20	3:30 A.M.	L. A. No. 3
7-15-20	3:30 A.M.	L. A. No. 15
7-15-20	5:21 A.M.	Eagle Rock
7-15-20	5:34 A.M.	Oil Wells
	7:17 A.M.	
	7:19 A.M.	
7-15-20	5:45 A.M.	Eagle Rock
	5:47 A.M.	
7-15-20	6:07 A.M.	Fernando
	to	
	12:42 P.M.	
7-15-20	6:25 A.M.	Lancaster
8-24-20	2:33 A.M.	Lindsay
8-24-20	10:55 A.M.	Colton
10-30-20	1:08 A.M.	Eagle Rock
10-30-20	1:19 A.M.	Chino
	2:50 A.M.	
	&	
	2:53 A.M.	
10-30-20	1:54 A.M.	Fernando
10-30-20	1:54 A.M.	Castaic
10-30-20	1:55 A.M.	Azusa
	2:10 A.M.	
	6:50 A.M.	
10-30-20	2:10 A.M.	Azusa
	6:37 A.M.	
10-30-20	2:21½ A.M.	Puente
	4:05½ A.M.	
11-6 -20	4:50 P.M.	Korn No. 1
11-6 -20	5:11 P.M.	Saticoy
11-6 -20	9:21 P.M.	Eagle Rock

1921

Date	Time	Location
1-22-21	1:41 P.M.	Cudahy Plant
	1:45 P.M.	Wilson's Plant
1-22-21	2:09 P.M.	Oil Wells
1-22-21	2:32 P.M.	L. A. No. 14
1-22-21	2:40 P.M.	San Fernando
1-22-21	2:40 P.M.	Eagle Rock
1-22-21	2:40 P.M.	McNeil
1-22-21	2:40 P.M.	Eagle Rock
1-22-21	3:04 P.M.	San Fernando
1-22-21	3:23 P.M.	L. A. No. 3
1-22-21	4:36 P.M.	Redondo
1-22-21	4:36 P.M.	Vernon
9-1-21	7:09 P.M.	Moorpark
9-1-21	7:51 P.M.	Visalia
9-1-21	9:43 P.M.	Mt. Whitney
	9:49 P.M.	

1922

Date	Time	Location
1-29-22	5:56 P.M.	Katella
1-30-22	12:50 P.M.	Chino
1-30-22	1:50 P.M.	Colton
5-15-22	10:43 A.M.	Big Creek Lines
		Local circuit at B. C.
5-15-22	3:07 P.M.	Mt. Whitney System
6-13-22	2:25 A.M.	Near Magunden
6-24-22	6:50 P.M.	Azusa
8-28-22	3:55 A.M. to	Mt. Whitney System
	1:18 P.M.	
8-28-22	2:30 P.M.	Lancaster
8-28-22	2:39 P.M.	Borel
8-28-22	3:19 P.M.	Between Oak and Monolith
8-28-22	4:46 P.M.	Lancaster
8-28-22	8:49 P.M.	Lancaster
9-19-22	12:30 P.M.	Redlands

1923

Date	Time	Location
4-10-23	11:00 A.M.	San Bernardino
4-10-23	11:37 A.M.	Redlands
4-10-23	11:37 A.M.	San Bernardino
4-18-23	10:40 A.M.	Colton
4-18-23	12:13 P.M.	Azusa
4-18-23	12:14 P.M.	San Antonio
4-18-23	12:43 P.M.	Puente
4-18-23	1:24 P.M.	Puente
4-18-23	1:33 P.M.	Dalton
4-18-23	1:57 P.M.	Azusa
4-18-23	2:14 P.M.	Eagle Rock
8-11-23	10-06 P.M.	Monolith Cement Plant
9-2 -23	3:05 P.M.	Monolith
9-8 -23	2:08 P.M.	San Bernardino
9-11-23	6:49 P.M.	San Bernardino
9-12-23	4:45 A.M.	Mojave
9-12-23	7:53 A.M.	Lancaster
9-12-23	10:09 A.M.	Monolith
	10:11 A.M.	
9-12-23	10:55 A.M.	Fairview
9-12-23	12:00 P.M.	Lancaster
9-12-23	12:17 P.M.	Lancaster
9-12-23	2:50 P.M.	Lancaster
9-13-23	12:12 P.M.	Newmark
9-13-23	1:09½ P.M.	Castaic
10-31-23	2:15 P.M.	M. C. No. 1
10-31-23	5:05 P.M.	L. A. No. 3
11-6 -23	4:58 P.M.	Colton
11-9 -23	9:40 A.M.	Mill Creek
11-9 -23	10:02 A.M.	San Bernardino
11-30-23	10:26 P.M.	Torrance
11-30-23	10:47 P.M.	Los Alamitos
11-30-23	10:47 P.M.	Los Alamitos
11-30-23	10:50 P.M.	Katella
11-30-23	10:53 P.M.	Katella
11-30-23	10:54 P.M.	Katella
11-30-23	10:55 P.M.	Katella
12-1 -23	2:38 A.M.	Colton
	2:40 A.M.	
12-24-23	No time	

Another value of an arrester is its application from the standpoint of what may be termed an "excess voltage deflector" if such a phrase may be coined. There have been many cases of 10-kv. lines accidentally coming in contact with 2.3-lines or of 60-kv. lines coming in contact with 10-kv. lines where the protective value of the arrester has been amply demonstrated. For this purpose alone, the use of arresters is justified on the lower voltage lines. In almost all of the cases just referred to, the arresters saved the station equipment on the lower voltage bus, whereas it is almost certain a fire would have resulted had there been no arresters on the lower voltage lines. In some cases the

No.	Station	Voltage of Circuit	Type	Location of Arresters in Station
	Altadena	15 kv.	Graded resistance	line
	Artesia	2.2 kv.	Multi chamber	bus
	Alhambra	60 kv.	Graded resistance	line
		15 kv.	" "	"
	Azusa	15 kv.	Aluminum cell	bus
	Bandini	60 kv.	Oxide film	line
	Bandini	15 kv.	Graded resistance	"
	Bardsdale	15 kv.	" "	"
	Bellflower	11 kv.	" "	"
	Belmont	11 kv.	" "	"
		2.2 kv.	Multi gap	"
	Beverly Hills	2.2 kv.	Graded resistance	bus
	Bicknell	15 kv.	" "	line
	Brea	11 kv.	" "	"
2 sets	Borel	60 kv.	Oxide film	"
	"	10 kv.	Multi gap	"
	Burbank City	15 kv.	Graded resistance	"
2	Castaic	60 kv.	Aluminum cell	"
	"	15 kv.	Multi gap, Aluminum cell	"
5	Chino	60 kv.	Aluminum cell	"
	"	11 kv.	Multi gap	"
	"	2.2 kv.	Aluminum cell	"
	"	2.2 kv.	Graded resistance, Street Lights	"
	Capistrano	70 kv.	Aluminum cell	"
	"	60 kv.	" "	"
	Culver City	60 kv.	Oxide film	"
	Carpenteria	60 kv.	Graded resistance	"
	"	11 kv.	" "	"
	Claremont	11 kv.	Multi gap	bus
2	Colton	60 kv.	Aluminum cell	line
5	"	30 kv.	" "	"
7	"	11 kv.	Multi gap	"
	Dalton	60 kv.	Graded resistance	"
	Delano	60 kv.	Aluminum cell	"
	Downey	2.2 kv.	Multi Chamber	"
	Ducor	11 kv.	Aluminum cell	"
	Earlimart	60 kv.	" "	"
	"	10 kv.	" "	bus
	El Monte	15 kv.	Graded resistance	line
	Exeter	11 kv.	Aluminum cell	bus
	"	2.2 kv.	" "	"
	Fairview	60 kv.	Oxide film	line
	Fullerton	60 kv.	" "	"
	"	10 kv.	Graded resistance	"
	"	2.2 kv.	Multi Chamber	"
	Filmore	60 kv.	Aluminum cell	"
	"	15 kv.	Graded resistance	"
	Fontana	11 kv.	Aluminum cell	"
	Garvey	15 kv.	Graded resistance	"
	"	2.2 kv.	Multi gap	"
	Graham	15 kv.	Graded resistance	"
	Highlands	10 kv.	Multi gap	"
	Inglewood	2.2 kv.	Multi Chamber	line
	Katella	60 kv.	Oxide film	"
	"	10 kv.	Aluminum cell	"
	Kaweah No. 1	33 kv.	Multi gap	"
	" No. 2	33 kv.	Aluminum cell	"
	" No. 3	33 kv.	" "	"
	Kern River No. 1	60 kv.	" "	"
	" " No. 3	60 kv.	" "	"
	Laguna Beach	10 kv.	Graded resistance	"
	" "	2.2 kv.	Multi gap (St. lights)	"
	Laguna Bell	60 kv.	Oxide film	"
	La Habra	10 kv.	Graded resistance	"
	La Verne	10 kv.	Multi gap	"
	" "	2.2 kv.	" "	"
	Lindsay	30 kv.	Aluminum cell	bus
	"	30 kv.	" "	"
	"	10 kv.	" "	"
	Los Alamitos	60 kv.	Graded resistance	line
	" "	10 kv.	" "	"
	Long Beach Steam	60 kv.	Aluminum cell, Oxide film	"
	" " "	10 kv.	" " Graded resistance	"
	L. A. 3	60 kv.	Oxide film	"
	L. A. 3	30 kv.	" "	"
	L. A. 3	15 kv.	Graded resistance	"
	Los Cerritos	10 kv.	" "	"
	Lynwood	15 kv.	" "	"
	Lytle Creek No. 1	10 kv.	Aluminum cell	"
	MacNeil	60 kv.	Oxide film	"
	"	15 kv.	Graded resistance	"
	MacNeil	2.2 kv.	Multi gap (not installed)	line
	Maywood	12 kv.	Graded resistance	"
	Mill Creek 2-3	30 kv.	" "	"
		10 kv.		
	Monolith	60 kv.	" "	"
	"	10 kv.	Resistance	"
	Montecito	10 kv.	"	bus
	Montrose	15 kv.	Graded resistance	line
	Newport	2.2 kv.	Multi Chamber	"
	Norwalk	10 kv.	Graded resistance	"
	Ojai	15 kv.	Multi gap	"
	Ocean Park	15 kv.	Aluminum cell	"
	Oxnard	15 kv.	Graded resistance	"
	"	4.4 kv.	Multi gap	"
	Packwood	10 kv.	Aluminum cell	"
	Pedley	60 kv.	Graded resistance	"
	"	10 kv.	" "	"
	Pomona	10 kv.	Multi gap	"
	Porterville	60 kv.	Oxide film	"
	"	30 kv.	Aluminum cell	bus
	"	10 kv.	" "	"
	"	2.2 kv.	" "	"
	Puente	60 kv.	" "	line
	"	10 kv.	" "	"
	"	2.2 kv.	Multi gap (Street lights)	"
	Redlands	10 kv.	" "	"
	Redondo Steam	15 kv.	Aluminum cell	"
	" Sub	2.2 kv.	Multi gap (St. lights)	"
	San Antonio	60 kv.	Water column type	"
	San Bernardino	30 kv.	Oxide film	"
	" "	10 kv.	Graded resistance	"
	" "	2.2 kv.	Multi Chamber	"
	San Dimas	10 kv.	" "	"
	San Fernando	15 kv.	Aluminum cell	"
	San Gabriel	15 kv.	Oxide film	"
	" "	2.2 kv.	Multi Chamber	"
	S. A. R. No. 1	30 kv.	Aluminum cell	"
	S. A. R. No. 3	30 kv.	" "	Bus
	Santa Barbara	60 kv.	" "	line
	" "	2.2 kv.	Multi gap	"
	Santa Fe Springs	10 kv.	Graded resistance	"
	Santa Paula	15 kv.	" "	"
	Saticoy	60 kv.	" "	"
		15 kv.	" "	"
	"	4.4 kv.	Multi gap	"
	Sawtelle	15 kv.	Aluminum cell	"
	Sierra	15 kv.	" "	"
	Sierra Madre	2.2 kv.	Multi gap	"
	Strathmore	11 kv.	Aluminum cell	"
	Success	11 kv.	Oxide film	bus
	Saugus	60 kv.	" "	line
	"	15 kv.	Graded resistance	"
		4.4 kv.	Auto valve	
	Terra Bella	60 kv.	Aluminum cell	bus
	" "	10 kv.	" "	"
	Tipton	60 kv.	" "	"
	"	10 kv.	" "	"
	Torrance	60 kv.	" "	line
	"	15 kv.	" "	bus
	Tulare Sub	60 kv.	" "	"
	" "	10 kv.	" "	"
	" "	2.2 kv.	" "	"
	Tule River	30 kv.	" "	"
	Venice Hills	60 kv.	Oxide film	line
	" "	10 kv.	Aluminum cell	bus
	Venida	60 kv.	Graded resistance	line
	"	30 kv.	" "	"
	"	10 kv.	" "	"
	Venice	2.2 kv.	Multi chamber	"
	Vernon	60 kv.	Aluminum cell	"
	"	15 kv.	" "	bus
	Vestal	60 kv.	Oxide film	line
	"	10 kv.	Graded resistance	"
	Visalia	60 kv.	" "	"
	"	10 kv.	" "	"
	"	2.2 kv.	Multi chamber	"
	Westflor	60 kv.	Oxide film	"
	"	15 kv.	Graded resistance	"
	Whittier	10 kv.	Aluminum cell	"
	Woodville	60 kv.	Graded resistance	"
	Yucaipa	10 kv.	Multi gap	"
	Watson	10 kv.	Graded resistance	"

arrester was damaged, but this was more than compensated for by the protection afforded the station apparatus.

As a general practise throughout the system, use has not been made of lightning arresters to protect distribution transformers. In some of the districts located

Fig. 5—Typical Late Design Arrester set-Up at Laguna Bell Station. Oxide Film Arrester on 60-Kv. Line

Fig. 6—Typical Small Station Arrester Set-Up Graded Resistance Type of Arresters on 11-Kv. Line—Lynwood Substation

at the higher elevations (2000 feet and above) and in other districts located along the foothills of the Sierra Madre range, it appears that lightning storms are of sufficient frequency to justify the use of arresters to protect distribution transformers. Observations indicate that the Lancaster district, located at an elevation of approximately 2000 feet in the Antelope Valley, on the edge of the Mojave desert, has sufficient periodical lightning disturbances to justify the installation of arresters to protect each transformer bank. A few years ago, in the district, an experiment was made to protect all of the distribution transformers supplying pumping plants in a section of four square miles. No other distribution transformers were protected by lightning arresters. After the first severe lightning storm it was found that in the area where the lightning arresters were used, no transformers were damaged, while outside of this area a total of seven transformers had to be replaced. This experiment indicated in a small way the value of this type of protective equipment. Steps are now being taken to install an inexpensive type of arrester at the majority of pumping plants located in districts subject to annual lightning disturbances.

Throughout the whole system, with the exception of the highest voltage lines (150 kv. and 220 kv.) the installation of lightning arresters on new stations is now an established policy. The older stations also are gradually being equipped with this valuable protective device, for it is felt that its use is well justified from a standpoint of insurance against damage to apparatus and unnecessary interruptions to service.

ILLUMINATION ITEMS

By the Lighting and Illumination Committee

THE INCREASING IMPORTANCE OF LIGHT IN INDUSTRY

To the man who sees in the promotion of good lighting an opportunity for service, this article is nothing short of an inspiration; to him who is satisfied to supply merely what his customer asks for, regardless of its adequacy, it sounds a warning. The following article formed the editorial feature of *Electrical World* for September 29th, 1923, and is printed by permission.

Electricity has been a boon to mankind in many ways. It has served to produce light when and where it was wanted; it has come to perform the tasks of industry and of the household; it is used directly in manufacturing processes of various kinds; it provides warmth; it provides flexibility, and the electrical industry has been constantly at work devising new ways in which it can serve. But it was only recently that there came a realization that light, the earliest form of service by electricity, had much latent ability to be of far greater service than had previously been thought possible.

All early work by illuminating engineers in their attempt to provide adequate light in factories and other industrial establishments was directed toward the proper distribution of light to give a virtually uniform illumination of an intensity recognized as sufficient for "good vision." Light in its relation to production was considered solely from the standpoint of a substitute for waning daylight. But it is characteristic of engineering development that study and analysis continued until

it was definitely shown that the intensity or degree of illumination was a vital factor in increasing production in all kinds of work. No longer was it a question of determining whether the light satisfied the average investigator or the average workman as being enough to enable him to "see his work well." Rather, were definite data gathered to show that as intensity increased so did production. The engineer does not yet know to what intensity it is desirable to go. It is known that on changing from 3 to 4 foot-candles to 15 or 20 or 30 foot-candles, there is a definite increase in productivity. Some experiments indicate that 50 foot-candles is not too high, and some able and experienced engineers talk in hundreds.

Enough, however, is now known on the subject to cause many manufacturing executives to realize that illumination does play a real part in the productive effectiveness of their plants. They can see that by increasing the expenditure for light by three or four or six times they have to increase only one of the very small elements of the manufacturing costs and that the returns on this expenditure are manyfold.

From the standpoint of the illuminating engineer, the problem of lighting in industry thus presents many new aspects. He is no longer merely a calculator of illumination intensities. He has to consider his contribution to the producing ability of the plant, and the actual illumination studies he makes are complicated by the intrusion of glare and similar problems on account of the intensities used. Requirement and opportunity exist for a great deal of illuminating engineering ability in the successful application of this newly developed philosophy of industrial illumination. Only a small part of industry has so far reaped the benefits, but from now on surely no engineer charged with the layout of a factory and no illuminating engineer charged with the problem of lighting it can fail to consider fully the relation of the illumination to that factory's production.

RE-LIGHTING THE GAS STATION*

The gasoline filling and service station has come forth from the garage where it formerly led a relatively quiet and obscure existence, boldly to take its stand in the high places alike of business thoroughfare and residental street.

The invasion, by this essential adjunct to modern transportation, of business, pleasure, and residental centers has been accompanied by a remarkable evolution in the station itself from an architectural viewpoint, in the attention given to its immediate surroundings, and in the kind and amount of service which it renders to its patrons.

The sheet metal shelters of but a short time ago are rapidly giving way to structures of permanency and architectural refinement; the surroundings of the station are beautified and landscaped to correspond with their environment and no stone is left unturned to give the patrons' requirements complete, rapid, and courteous attention.

So definitely has the factor of attractive appearance allied itself with their sales results that the more enterprising companies have sized up the loss to be sustained, if any of this attracting powe ris lost, when daylight fails, and are giving special attention to that kind of artificial lighting which will preserve if not actually add greater beauty to the day-time attractiveness.

While playing its role in giving the station a fine "ready-to-serve" appearance, good illumination takes a part of no less importance in actually making it possible for customers to receive that high grade of service which they expect. With this aid the motorist easily determines his requirements for gas and oil, air, and water, and has them expeditiously supplied by an attendant using lighted equipment.

This station is lighted by twelve 500-watt clear gas-filled lamps in basket lanterns equipped with light alabaster rippled glass globes and dome refractors. The mounting height of the luminaries is twelve feet. Interior of station is lighted by one 500-watt clear lamp in totally enclosing glassware. Twenty-four 60-watt clear tungsten lamps located in trough at cornice "floodlight" station house. Beacon employs one 200-watt clear lamp. Behind the word "Gasoline" in the sign are sixteen 50-watt lamps fitted with ruby color-hoods. Average illumination on driveways and service area is 3.5 foot-candles.

RE-LIGHTING THE GAS STATION

*Light, Cleveland.

FLOODLIGHTING A CHURCH AT NIGHT

The Hennepin Avenue Methodist Church, Minneapolis, is now equipped with a battery of electric flood lights which are used to display its beauty after dark. These giant electric lamps are placed a short distance from the church and when lighted they make the edifice stand forth bathed in brilliant light. This has made the church one of the architectural attractions of Minneapolis.—S .E. D. Service.

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The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Annual Convention at Edgewater Beach Chicago

As this issue of the JOURNAL goes to press, the Annual Convention is in progress at Edgewater Beach, Chicago. A total of about 750 guests has registered. The Delegates' Conference and the Session on Tuesday were well attended, and a lively discussion followed. Visitors to the convention have many opportunities for a most enjoyable week, as there are various places of engineering and historic interest in the vicinity, and the Convention Committee has planned numerous social features for their entertainment. A detailed account of the convention will be given in the August JOURNAL.

The Pasadena Convention and Excursion Trip

The combination of a delightful excursion trip, a visit to California and some very informative technical sessions will lead many members to attend the Institute Convention at Pasadena, October 13 to 17. Just now the interest is growing in the proposed excursion trip through the West. This trip offers an exceptional opportunity to see some of the wonders of this country under very congenial conditions. The plan is to have a special train or cars in which the trip from the eastern part of the country can be made.

A number of the pioneers of the Institute and other prominent members have been invited to make this trip and to be present in a reunion at the meeting.

The route will be through Colorado Springs, Royal Gorge, Salt Lake City, Feather River Canyon, San Francisco, Yosemite and Los Angeles. Stops will be made at the interesting places and those who care to may take a number of side trips. There will be a choice of local excursions or complete freedom, as desired by the individuals. In returning, any one of the several ways may be chosen but the Grand Canyon will naturally be included in the routes of many.

All members who think they will probably join in this excursion will confer a favor on the committee in charge if they will kindly send word to this effect to Institute Headquarters, New York.

As to the cost of the trip, rather complete information was given in the June issue of the JOURNAL, page 572. A general estimate may be made if it is stated here that the round trip from New York to Los Angeles, including stopovers and a side trip to the Grand Canyon, will amount to about $147. An upper berth will cost about $62 and a lower berth about $78. The rates from points other than New York, of course, are different in accordance with the distance.

Among the unusual features of the convention will be the meeting already mentioned at which the pioneers will talk and reminisce on the problems that were uppermost many years ago and the ways in which those problems were solved. Both old and young members should enjoy such talks as these.

Among the technical papers, transmission, electrophysics, application, telephony, distribution and other subjects will be covered. On account of the great developments in transmission which are under way on the Pacific Coast, this subject will be one of the most widely discussed. Some notable work on high-voltage lines and corona will be presented.

The famous Norman Bridge Laboratory, with which R. A. Millikan is connected, will offer a noteworthy group of papers on some of the latest advances in electrophysics.

The application of electrical power to a number of Western industries will be covered by a group of papers which should be of particular interest to the application engineer. Among the industries included are irrigation, oil refining, electrometallurgy, lumber mills, cement mills, iron and steel and mining. A session will be devoted to telephony and one or two exceptional papers will be presented on electrical machinery.

All plans are very well advanced and the Convention Committee is mapping out a most interesting program. This committee is composed of the following members: R. W. Sorensen, Chairman; O. F. Johnson, Secretary; M. O. Bolser, E. E. F. Creighton, H. B. Dwight, E. R. Hannibal, C. R. Higson, W. C. Heston, C. W. Koiner, J. A. Koontz, Jr., C. A. Lund, F. W. MacNeil, S. G. McMeen, L. W. W. Morrow, E. F. Pearson and E. R. Stauffacher.

Northeastern District Holds Meeting of High Character

Highly successful in every way was the convention held on June 4 and 5 at Worcester, Mass., by Geographical District No.1. There were two very busy days filled with good papers, enjoyable entertainment and profitable inspection visits. About 275 engineers were registered at the meeting and a very large proportion of this number consisted of prominent members of the Institute.

VERY GOOD PAPERS

Among the large group of excellent contributions there were two outstanding papers. These were *A New Type of High-Tension Network* by Percy H. Thomas, and *The Development of a Suspension-Type Insulator* by Harold B. Smith.

The paper by Mr. Thomas set forth a plan for a superpower system which consists of a many-branched network of single-circuit lines. These lines are of low current-carrying capacity in comparison with trunk lines which would serve the same area. Considerable discussion followed the paper and this was taken part in by H. A. Stanley, W. A. Moore, L. W. W. Morrow, W. J.

Rosch, F. L. Hunt, C. E. Skinner, F. J. Adams, C. R. Oliver, Farley Osgood, C. F. Scott, and H. L. Smith.

Professor Smith told of what seemed to many to be a pioneer step in the construction of a new form of insulator for high-voltage lines, one insulator unit serving for 110,000 volts, two for 220,000 and three for 330,000 volts. The discussion, which included much of interest regarding the former problems of insulators as well as the modern problems. was entered into by E. M. Hewlett C. E. Skinner, C. F. Scott, Y. Nagashima, B. Karapetoff, F. L. Hunt and H. A. Stanley.

Another most interesting presentation was that by G. H. Browning of the paper by himself and Fred Drake *An Efficient Tuned Radio-Frequency Transformer*. Those discussing the paper were W. A. Curry, C. E. Skinner, R. C. Lawrence, C. F. Scott, E. H. Hubert and J. A. French.

Transformers for High-Voltage Testing by F. B. Cahall was discussed by W. A. Curry, W. A. Del Mar, F. W. Peek, S. J. Rosch and E. D. Eby.

An instrument for indicating in service the point at which a distribution transformer is being overheated was described in the paper, *Thermotel* by E. D. Treanor, The discussors of the paper were A. E. Kennelly, G. G. Jeter, W. H. Cooney, V. M. Montsinger and H. M. Hobart,

A paper on *Windmill Generator Plants*, by F. C. Doughman, was discussed by H. H. Clark and H. M. Hobart.

Three excellent papers on electrical machinery were given at an evening meeting. The first of these, *Effects of Expansion and Contraction on Insulation of Long Armature Coils* by T. S. Taylor was discussed by P. L. Alger and F. D. Newbury. The second paper, *Short Circuits in Alternating-Current Generators*, by C. M. Laffoon. was discussed by Prof. V. Karapetoff. The third paper, entitled *Torque Pulsations in Single-Phase Motors*, was presented by P. L. Alger and A. L. Kimball. The discussion was by Messrs. Weber, Newbury, Summers and Hertz.

Banquet and Addresses

A most enjoyable banquet was attended at the Bancroft Hotel on Wednesday evening, June 4. After an address of welcome by Mayor O'Hara of Worcester, G. Faccioli, Vice-President of the Northeastern District spoke briefly of the commendable way in which the committee at Worcester had arranged the convention which, he said, would make history in the Institute. He then introduced President-elect Farley Osgood who spoke very interestingly on the convention, and a number of other important Institute matters.

N. F. Hanley then presented a paper *The Industrial Compass* which outlined a method of forecasting future business conditions. *Continuous Threads of Activity* was the theme of a talk by V. Karapetoff in which he outlined a unique philosophy of life and a plan by which an individual might guide all of his activities. C. F. Hood presented a film which showed the laying of a high-voltage cable across the bay at San Francisco. C. F. Scott described very briefly the "transient visualizer" which has been developed by H. B. Turner.

Between the addresses throughout the evening delightful music was furnished by a vocal quartette and an instrumental trio.

Visits of Inspection

Among the inspection trips was a visit to a plant of the American Steel and Wire Company where the members viewed the various processes employed in manufacturing insulated wires, high-voltage cables, wire rope and other products. Another trip was to the Millbury substation of the New England Power Company which is the dispatching headquarters of the Company. A new 110,000-volt line designed for an ultimate 220,000-volt circuit ties into this substation and this proved to be especially interesting.

During the convention the laboratories of Worcester Polytechnic Institute were inspected by many of the visitors. Other trips were made to the Norton Company's plant and to stations of the Worcester Electric Light Company.

International Mathematical Congress

An International Mathematical Congress will be held in Toronto, Canada, from Monday, August 11th to Saturday, August 16th, 1924, under the auspices of the University of Toronto and the Royal Canadian Institute. The Congress will be conducted in conformity with the regulations of the International Research Council and it is expected the A. I. E. E. will be represented by two delegates in accordance with the invitation received. The arrangements for this Congress will be in the nature of a departure from previous Congresses in that a far greater scope for contributions of interest to engineers is planned. Section IV-a will deal with electrical, mechanical, civil and mining engineering; and Section IV-b with aeronautics, naval architecture, ballistics and radio telegraphy. The mathematical aspect of papers may be considered in a measure subservient to their practical value. The Organizing Committee hopes that it will be possible for many members of the A. I. E. E. to contribute. Abstracts should be mailed to the Secretary of the Organizing Committee, International Mathematical Congress, 198 College Street, Toronto, Canada.

Annual Meeting of New York Electrical Society

At its annual meeting for the election of officers June 5th, the New York Electrical Society unanimously elected the following ticket, with Vice-Presidents, H. A. Kidder, A. Cane, E. H. Clark, as holdovers:

President, Dr. Erich Hausmann; Vice-Presidents, S. G. Rhodes, W. S. Murray, A. E. Allen; Secretary, H. E. Farrer; Treasurer, David Darlington.

1924 Commission of Washington Award to Arthur N. Talbot

The Commission of Washington Award for 1924 was voted to Arthur Newell Talbot, University of Illinois and the presentation was made at the annual meeting of the Western Society of Engineers, held June 9, 1924. The award was made to Prof. Talbot for his life work as student and teacher, investigator and writer and for his enduring contribution to the science of engineering.

The award is made annually by a committee composed of nine representatives of the Western Society of Engineers and two each from the A. S. C. E., the A. I. M. E., the A. S. M. E. and the A. I. E. E. The award of the medal was established in 1917 by Past President J. W. Alvord of the Western Society "to be annually presented to an engineer whose work in some special instance, or whose services in general have been noteworthy for their merit in promoting the public good."

The 1924 award is the third; the first was made in 1919 to Herbert Hoover, the second in 1922 to Capt. Robert W. Hunt.

American Engineering Standards Committee

STANDARDIZATION—WHAT IT IS DOING FOR INDUSTRY

A booklet entitled "Standardization—What it is doing for Industry" has recently been issued by the A. E. S. C. It points out how standardization eliminates to a great extent needless waste in time, money and energy, both during war and in time of peace and describes the three stages of standardization; the standardizing of materials in the factory and industries; the standardizing of specifications by the Government and various societies; and national standardization; which is now being correlated through the American Engineering Standards Committee.

The A. E. S. C., 29 W. 39th St., New York City, will furnish copies of this booklet upon request.

Engineering Societies Library

The library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES MAY 1-31, 1924

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statements made; these are taken from the preface or the text of the book.

All the books listed may be consulted in the Engineering Societies Library.

ADMINISTRATION OF VOCATIONAL EDUCATION.

By Arthur F. Payne. N. Y., McGraw-Hill Book Co., 1924. 354 pp., tables, 9 x 6 in., cloth. $3.00.

Dr. Payne's object is a distinctly practical one. He devotes but a brief space to the discussion of the theory and principles of vocational education, confining himself chiefly to practical methods for industrial education. He develops methods, standard, requirements and practises for the organization and administration of schools and classes, which will interest supervisors and directors of vocational education. A good bibliography is included.

ALTERNATING-CURRENT CIRCUIT.

By Philip Kemp. Lond., & N. Y., Isaac Pitman & Sons, 1923. 88 pp., diagrs., 7 x 5 in., cloth. $.75.

A brief introduction to alternating-current work, intended to give a clear but simple explanation of the various phenomena exhibited by the alternating-current circuit. It does not attempt to deal with machinery and apparatus.

ANHALTSZAHLEN FUR DEN ENERGIEVERBRAUCH IN EISENHUTTENWERKEN.

By Verein deutscher Eisenhüttenleute. Düsseldorf, 1922. 74 pp., diagrs., tables, 10 x 7 in., paper. $1.75. (For sale by P. E. Hermann, Century Bldg., Pittsburgh, Pa.)

This collection of detailed data on the energy requirements in iron and steel works is of interest to all those engaged in the industry. The figures given have been collected from the literature and from practise in the German works which support the Warmstelle Düsseldorf, and are representative of current practise. Data are given on the consumption of energy in coke works; blast-furnaces; open-hearth, bessemer, crucible and electric steel furnaces; rolling mills; heating furnaces; producer plants; steam and gas engines; and the accessory machinery. An unusual compilation of data on the fuel consumption of an important industry.

ARTILLERIE DE COMPAGNE.

By Lt.-Col. Rimailho. Paris, Gautheir-Villars et Cie., 1924. 506 pp., illus., diagrs., 11 x 7 in., paper. 55 fr.

This volume attempts to point out the probable course of the evolution in artillery science which will result from the lessons of the World War. The book reviews the development of field artillery in France from the Franco-Prussian War to the end of 1918 and then discusses future developments, this discussion occupying the greater part of the book. The author is an advocate of automotive artillery and devotes much space to them.

The writer was one of the designers of the French 75-mm. gun and the creator of the 155 mm. Rimailho gun, the only heavy gun that the French army had at the Battle of the Marne.

CALCULUS OF OBSERVATIONS; A Treatise on Numerical Mathemathics.

By E. T. Whittaker and G. Robinson. N. Y., D. Van Nostrand Co., 1924. 395 pp., 9 x 6 in., cloth. $6.00.

Although a knowledge of the mathematical problems that arise in dealing with numerical data are attractive and important to engineers, physicists, naval architects, and other scientists, there has been until recently little instruction on the subject in most universities. The present book represents the lectures given in the Mathematical Laboratory of the University of Edinburgh during the past ten years. It discusses such problems as interpolation, central-difference formulas, the numerical solution of algebraic and transcendental equations, numerical integration and summation, frequency distributions, the method of least squares, practical Fourier analysis, the smoothing of data, correlation, the search for periodiceties and the numerical solution of differential equations. The methods given are exclsuively arithmetical.

CHEMICAL ELEMENTS.

By F. H. Loring, N. Y., E. P. Dutton & Co., 1923. 171 pp., 9 x 6 in., cloth. $3.75.

The aim of this book is to present in a simple, concise form certain characteristics of the chemical elements as studied from the viewpoint of their quantitative grouping and their structural binding, and to bring into prominence the significance of "space physics" as applied to certain phenomena. The author discusses isotopes, atomic numbers, numerical relations and missing elements in the periodic table, the distribution of the elements, element evolution, the quantum theory, electron binding, space geometry, radiation and energy, radio-activity, the synthesis of elements on a commercial scale, and other important topics. The book is based on recent work and attempts to present the subject in straightforward fashion.

CHOICE OF SWITCHGEAR FOR MAIN AND SUB-STATIONS.

By W. A. Coates. N. Y., D. Van Nostrand Co., 1924. 292 pp., illus., diagrs., 10 x 7 in., cloth. $6.00.

The viewpoint taken in this work is that of the user of switchgear who is not a specialist. Details of construction are given only to an extent sufficient to enable him to compare competitive offers intelligently. Circuit equipments, main switching systems and forms of switchgear construction are presented at length, to facilitate the selection of the most appropriate equipment and the preparation of the necessary purchasing specifications. The book follows British practise and conforms to the regulations controlling the construction and use of switchgear in that country.

COLLIERY ELECTRICAL ENGINEERING

By G. M. Harvey, Lond. & N. Y., Isaac Pitman & Sins, 1924. 387 pp., illus., diagrs., tables 9 x 5 in., cloth. $4.50

A treatise on the application of electrical power to mining, for readers with a working knowledge of the theory of direct and alternating currents. The book treats specifically of conditions in English coal mines. The layout, equipment and maintenance of an electrical installation, above and below the surface, are considered in all the various applications.

Color and Methods of Color Reproduction.

By L. C. Martin. N. Y., D. Van Nostrand Co., 1923. (Applied physics series.) 187 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.00.

This book is divided into three sections. The first gives a simple account of the chief facts of the theory of color measurement and nomenclature and seeks to show how the theory may help our practise in certain directions. The second section is an introduction to the more advanced study of color measurement and color vision; and the third treats of color photography and color printing by William Gamble. The book is intended to stimulate investigation in this field and also to be useful to those dealing with color in commerce and art.

Conduit Wiring.

By Terrell Croft. N. Y., McGraw-Hill Book Co., 1924. 458 pp., illus., diagrs., 9 x 6 in., cloth. $3.00.

This book is devoted exclusively to the conduit method of interior wiring. It is intended primarily for the man who installs wiring, and who will find here a more detailed exposition of this method than that given in most books on interior work. The steps and operations necessary in modern work are discussed and explained, and the usual procedures in wiring buildings of all kinds, from small residences to large office and shop buildings, are set forth.

Direct Dynamo and Motor Faults.

By R. M. Archer. Lond. & N. Y., Isaac Pitman & Sons, 1924. 204 pp., diagrs., 7 x 5 in., cloth. $2.25.

This little book is intended to assist students and those in charge of direct-current machinery in the location of sources of trouble and in the application of proper remedies. Part one describes the more common faults that arise and the symptoms that their occurrence causes. In part two the arrangement is by symptoms, with appropriate diagnoses of the trouble.

Electric Elevator Equipment for Modern Buildings.

By Ronald Grierson. N. Y., D. Van Nostrand Co., 1924. 179 pp., illus., tables, 9 x 6 in., cloth. $5.00.

This, the first book on electric elevators published in England, is intended for engineers and architects in need of a simple, concise account of general principles and practises which will serve as a guide to their selection, installation, operation and maintenance. It is based upon a series of articles published in the "Builder" but has been expanded and revised. Passenger and freight elevators, dumb waiters and escalators are discussed. The book is chiefly based on the scattered literature of the subject.

Electrical Engineering Practise, v. 1.

By J. W. Meares and R. E. Neale. 4th edition, enl. N. Y., John Wiley & Sons, 1924. 584 pp., illus., diagrs., tables, 9 x 5 in., cloth. $6.00.

This work endeavors to fill the gap between the pocket-book of bare data and the highly technical treatises for specialists in various branches of electrical engineering. It is intended for civil, mechanical and electrical engineers alike, who wish a reference book covering the whole field in reasonable limits. Four editions have been called for in eight years.

The new edition has been enlarged and rearranged and published in two volumes. The first volume treats of definitions, materials, measurements, the generation and sale of electrical energy, and its transmission and control. The treatment is practical throughout.

Electrical Measuring Instruments, Pt. 1; Commercial and Indicating Instruments.

By C. V. Drysdale and A. C. Jolley. Lond., Ernest Benn, 1924. 440 pp., illus., diagrs., tables, 10 x 7 in., cloth. 55s.

Contents: General electrical principles.—Mechanical design and construction.—Conditions of rapid indication.—Elements of electrical theory and design.—Properties of electrical materials.—Permanent magnet moving coil instruments.—Soft iron instruments.—Dynamometer ammeters, voltmeters nad wattmeters.—Hot-wire indicating instruments.—Electrostatic instruments.—Apx.—Index.

Although there are many books on electrical measuring instruments, the authors of this work feel that there still is need for another, which will be to the designer and constructor of instruments what the various books on dynamo design and similar subjects are to the electrical engineer. The present work is intended to meet this need and also to give the user of instruments detailed information about important points of construction and performance of the many types on the market. The present volume deals almost entirely with direct indicating instruments; laboratory instruments have been left for consideration later.

Elements of Water Bacteriology with Special Reference to Sanitary Water Analysis.

By Samuel C. Prescott and Charles-Edward A. Winslow. 4th Edition. N. Y., John Wiley & Sons, 1924. 211 pp., tables, 9 x 6 in., cloth. $2.25.

This work, first published nearly twenty years ago, attempts to present an account of the best American practise in this field of sanitary science, with sufficient completeness to be of value to the expert, and with such freedom from undue technicality that the layman may read it also. The present edition has undergone a radical revision. Matter now out of date has been omitted or condensed and attention has been concentrated upon the procedures that have been proven. The bibliography has been extended to June, 1923.

Die Fernsprechanlagen mit Wahler-Betrieb.

By Fritz Lubberger. 2d edition. München u. Berlin, R. Oldenbourg, 1924. 200 pp., illus., diagrs., 10 x 7 in., paper. $1.80.

A concise treatise on automatic telephony by the Chief Engineer of Siemens & Halske, which covers all branches of the subject. This new edition has been rewritten throughout and various proposals of merely theoretical interest have been eliminated to make room for new discoveries. Economic questions are also discussed thoroughly. The book is intended as a textbook for beginners. An appendix gives a detailed description of the Siemens & Halske system.

Die Gleichstrommaschine, v. 2; Arbeitsweise und Prüfung.

By Franz Sallinger. Berlin u. Leipzig, Walter de Gruyter & Co., 1924. 121 pp., diagrs., 6 x 4 in., boards. .30.

While the first volume of this convenient little introduction to the continuous-current dynamo and motor dealt solely with their internal structure, the present volume develops their external properties, as conditioned by their connections, and discusses them in relation to their many uses. The book will be of use to those who desire a very concise outline of modern theory and practise.

Handbook of Telehpone Circuit Diagrams with Explanations.

By John M. Heath. N. Y., McGraw-Hill Book Co., 1924. 279 pp., diagrs., plates, 4 x 7 in., fabrikoid. $2.50.

Gives, in the form of a convenient book for the pocket, seventy-two plates showing the circuits which comprise a telephone system, with explanations of their working. The circuits are arranged progressively, beginning with the simplest. Both local battery and common battery circuits are included. The book is intended for practical telephone men, as a handy reference work.

Hochstdruckdampf.

By Frederich Münzinger. Berlin, Julius Springer, 1924. 140 pp., illus., diagrs., 10 x 7 in., paper. $1.75.

In his new book, Dr. Münzinger continues his study of steam power by a critical examination of the advantages of high-pressure steam. He reviews the theoretical principles involved, the methods of generating and transporting high-pressure steam, and the methods of using it. The manufacture of high-pressure boilers and the relation of boiler cost to steam pressure are considered. Chapters are devoted to the economic prospects of high-pressure steam and to the new problems in heat economy, the latter chapter including a discussion of the mercury-vapor boiler. Emphasis is placed throughout on the economic and financial aspects of the question.

Die Isolierstoffe der Elektrotechnik.

By H. Schering. Berlin, Julius Springer, 1924. 392 pp., illus., diagrs., tables, 9 x 6 in., boards. $3.85.

During the winter of 1920-21 various specialists delivered lectures under the auspices of the Elektrotechnischer Verein and the Berlin Technical High School on electrical insulating materials. The interest exhibited led the Verein to commission Dr. Schering to prepare these addresses for publication, which has finally been accomplished. The lectures deal with the theoretical principles of insulation; natural insulants, marble, slate, asbestos and wood; mica and its products; ceramic insulants; plastics, paper and textiles; rubber, gutta-percha and balata; cellulose lacquers; mineral oils; and test-methods.

Jahrbuch der Elektrotechnik, v. 11, 1922.

By Karl Strecker. Münich u. Berlin, R. Oldenbourg, 1924. 241 pp., 10 x 7 in., boards. $4.50. (Received on Exchange)

The Jahrbuch covers the entire field of electrical engineering and gives in convenient form a concise review of the advances that were recorded during 1922. Fifty-eight articles by various

specialists summarize some 200 books and periodicals and combine the important data in continuous narratives. Full author and subject indexes and references to the sources of the data are included, making the book a convenient guide for students, investigators, and patent attorneys.

MASCHINENMESSKUNDE.

By L. Zipperer. Berlin u. Leipzig, Walter de Gruyter & Co., 1924. 116 pp., diagrs., 6 x 4 in., boards. .30.

This little handbook gives directions for making the measurements required in testing hydraulic turbines, pumps, blowers and steam engines, and describes the instruments used. Measurements of area, time, speed, power, pressure, volume, power, temperature, calorific power, etc., are included with a chapter on the evaluation of results.

POWER PLANT.

By David Moffat Myers. N. Y., Industrial Extension Institute, 1922. (Factory Management Course, v. 8). 615 pp., illus., diagrs., 7 x 5 in., fabrikoid. $7.50.

Contents: Basic principles and manufacture.—Field of investigation.—Nature and properties of steam.—Types and uses of steam boilers.—Boiler testing.—Boiler tests and chimney loss reduction.—Prime movers.—Testing of prime movers.—Factory heating.—Feed pumps and piping.—Water supply, pumps, treatment and heating.—Purchased power versus privately-owned plant. Investigation of a small factory plant. —Fuels and furnaces efficiency performances.—Coal and ash handling.—Electrical engineering.—Power Equipment as determined by local conditions.—Management systems.—Management notes.

This book is one of a series of textbooks prepared for a course on factory management. The present volume discusses the factory power problem. It is designed to direct the thought of the executive or factory engineer into channels that will guide him to a correct view of the power channels as a whole and enable him to evaluate the possibilities for power plant betterment.

POWER STATION EFFICIENCY CONTROL.

By John Bruce. Lond., & N. Y., Isaac Pitman & Sons, 1924. 244 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.75.

This is not a highly technical treatise but rather is a talk to power station engineers on the salient factors that influence efficient operation. The methods for efficient control which the author offers are those of the Electricity Department of the Glasgow Corporation. They cover the purchase and use of coal, boiler-room measurements, the tabulation and analysis of operating results, feed-water control, turbine-room efficiency, condensers and circulating water, electrical measurements and the control of auxiliaries. The appendix describes the "Parsons lines" and their use for the analysis of power-plant records.

PRACTICAL CALCULUS FOR HOME STUDY.

By Claude Irwin Palmer. N. Y., McGraw-Hill Book Co., 1924. 443 pp., diagrs., port., tables, 8 x 5 in., fabrikoid. $3.00.

This volume has been prepared in response to many requests for a simple, practical treatment of the ideas considered in the calculus, which have come to the author from men without college training, who have need for a working knowledge of the calculus and its practical applications. The author hopes that the book will give the man with limited mathematical training a thorough understanding of what the calculus is, when to use it and how; and that it will also be useful to the engineer as a reference and review book, because of the large number of solutions given.

PRACTICAL MATHEMATICAL ANALYSIS.

By H. von Sanden. N. Y., E. P. Dutton & Co., [1924]. 195 pp., illus., diagrs., tables, 9 x 6 in. cloth. $4.50.

Professor von Sanden's treatise on mathematical analysis lays particular stress on methods which have very general application, so that his work will be useful to students of engineering as an extension of their mathematical textbooks and lectures. All the methods discussed are developed with the principal object of providing means whereby the desired results may be expressed ultimately in numerical form. Much more attention is given to graphical methods, to the slide rule and to calculating machines than is customary in books on mathematics.

PRAKTISCHES MASCHINENZEICHNEN MIT EINFUHRUNG IN DIE MASCHINENLEHRE.

By Richard Schiffner. Berlin u. Leipzig, Walter de Gruyter & Co., 1923. 2 v., diagrs., 6 x 4 in., boards. $.30 each.

These two small volumes form a concise, practical textbook of mechanical drawing, suitable for home study as well as for use in technical schools. Volume one contains the general insructions, methods of drawing to scale and of making shop drawings. Volume two discusses the drawing and design of the ordinary elements of machines, bolts, screws, bearings, gears, etc.

STRENGTH OF MATERIALS.

By James E. Boyd. 3rd edition. N. Y., McGraw-Hill Book Co., 1924. 430 pp., diagrs., tables, 9 x 6 in. cloth. $3.50.

A textbook for the college student who has studied integral calculus and theoretical mechanics, which is intended to give him a grasp of the physical and mathematical ideas underlying the mechanics of materials, together with enough of the experimental facts and simple applications to sustain his interest, fix his theory and prepare him for the technical subjects given in the design of machines and structures. The new edition contains no great changes, but many minor modifications have been made.

SUPER-POWER AS AN AID TO PROGRESS

By Guy E. Tripp. N. Y., G. P. Putman's Sons, 1924. 61 pp., illus., maps, 8 x 5 in., cloth. $1.25.

The six addresses and articles by the Chairman of the Board of Directors of the Westinghouse Electric and Manufacturing Company which are collected in this volume call attention to some of the social, economic and political aspects of the "super-power" plan for the development of our power system. These papers avoid technical natters, being addressed to general readers, to whom they present the plan for consideration, with the arguments in favor of it.

SUPERVISION AND MAINTENANCE OF STEAM-RAISING PLANT.

By Charles A. Suckan. N. Y., D. Van Nostrand Co., 1924. 342 pp., illus., diagrs., 10 x 7 in., cloth. $8.00.

Contents: Pt. 1., Supervision; Working the power unit.—Attending to auxiliary appliances.—Care of subsidiary plant.—Management of staff.

Pt. 2, Maintenance; Upkeep of power unit.—Overhauling auxiliary plant.—Repairs to subsidiary plant.

This book deals with the scientific control of plants for producing steam. It is intended to assist owners, managers and engineers of power plants to operate them as efficiently as possible and also to indicate the type of service which the combustion engineer will render in days to come. The work covers the supervision or actual working of a plant and also the repair and overhauling of its components. Every subject connected with power-plant operation is discussed as simply as possible but with as much detail as is necessary for its efficient operation. Throughout, the author is concerned with operation rather than design.

TECHNICAL ORGANIZATION, ITS DEVELOPMENT AND ADMINISTRATION.

By John M. Weiss and Charles R. Downs. N. Y., McGraw-Hill Book Co., 1924. 197 pp., illus., 8 x 6 in., cloth. $2.50.

A discussion of the problem of organizing and maintaining a research and laboratory staff in an industrial concern, of the equipment necessary for satisfactory work, of the proper methods of operation, and of ways to determine the value of such an organization in terms of money. The authors write from practical experience. The book should interest employers who are concerned with scientific industrial development and directors of laboratories.

TRATTATO COMPLETO DI IDRAULICA TEORICA E SPERIMENTALE, v. 3; Azioni-Reazioni e Resistenza dei Fluidi.

By Donato Spataro. Milano, Ulrico Hoepli, 1924. 985 pp., illus., diagrs., tables, 9 x 7 in., paper. 80 lire.

This is the final volume of an unusually comprehensive treatise on theoretical and experimental hydraulics, by the professor of hydraulics in the Royal School of Engineers at Palermo. The present volume is concerned with the reactions and resistance of fluids, especially air and water.

Chapter one presents the general theory of impulses in hydromechanics. Chapter two treats of the reactions of water in motion, and chapter three of the pressure of a stream against a surface. In chapter four the resistance and relative motion of submerged and floating solids is considered; in chapter five, the action of gases on solids. Chapter six discusses the laws of homogeneity and similarity. Chapter seven, which occupies one-third of the volume, reviews the classic and modern experimental studies of flow of liquids and the resistance to flow of immersed solids.

Bibliography on Ventilation and Temperature Rise in Electrical Machines

The Engineering Societies Library has just compiled a bibliography (S 3921) on "Ventilation and Temperature Rise in Electrical Machines," which containes 73 references from the most important electrical periodicals for the last 10 years, with a few references between 1901 and 1913. This bibliography is for general sale at $15 a copy.

Manufacturers Contribute to the Engineering Library

The gratifying increase in the use made of the Engineering Societies Library has brought embarrassment as well as pleasure to its management, for the difficulty of maintaining it on an adequate scale has been increased greatly by its widening activities.

The chief support of the Library comes from the Founder Societies, the four national societies of civil, mining, mechanical and electrical engineers. These societies are not able to increase their appropriations as rapidly as the demands on the Library increase.

As much of the increased use of the Library is due to the enlarged interest of the industrial world in research, the situation of the Library was brought to the attention, early this year, of some of the industrial concerns that are making use of it. Many of them have immediately recognized the value of such a storehouse of information to their engineers and research workers and the advantages of keeping its equipment complete. Subscriptions have been received from a large number of important companies and others have the matter under consideration.

At the last meeting of the Library Board, the following resolution of thanks was adopted:

WHEREAS: In accordance with the instruction of the Board, the Secretary has written to a number of prominent organizations which have used the Library and its service, and asked for contributions toward its maintenance, and

WHEREAS: Many organizations have contributed and others, we are advised, are giving consideration to the matter; therefore be it

RESOLVED: That the hearty thanks of this Board be extended to those organizations that are enabling it, by their generous contributions in response to its statement of the condition of the Engineering Societies Library, to maintain the resources of the Library on a plane adequate to their needs for service.

HARRISON W. CRAVER,
Director, Engineering Societies Library.

PERSONAL MENTION

LEO GEENENS has recently become associated with the Dwight P. Robinson Co., 125 East 46th St., New York City.

F. F. EVENSON is now connected with the Benson Lumber Co., San Diego, Cal., having left the employ of the Bureau of Power and Light of Los Angeles, Cal.

JOHN W. CARROTHERS is no longer associated with the Colony Electric Company of Colony, Kansas, but is now with the Carrothers Company, Kansas City, Mo.

HERBERT BRISTOL DWIGHT of Hamilton Ont., received the degree of Doctor of Science on May 30th at the Annual Convocation of McGill University, Montreal, Que.

ARTHUR C. HOBBLE, after several months leave of absence is returning to his position as Chief Engineer of the Ebro Irrigation and Power Co., Apartado 491, Barcelona, Spain.

C. E. STRYKER has left the faculty of the Armour Institute of Technology, Chicago and is now Electrical Engineer with the Fansteel Products Company, North Chicago, Ill.

LOYAL R. MILBURN resigned from the General Electric Co., Cincinnati, Ohio, and is engaged in the construction of the new steam station of the Louisville Gas & Electric Co., Louisville, Ky.

WILLIAM F. NIEDRINGHAUS has accepted a position with the Socony Burner Corp., Brooklyn, N. Y. after severing his connections with the National Enameling & Stamping Co., Granite City, Ill.

ROBERT J. TORRENS has accepted a position with the Dwight P. Robinson Co., New York City, after severing his connections with the Bureau of Engineering, U. S. Navy Dept., Washington, D. C.

H. G. JENKS has severed his connections with the Eastern Mass. Electric Co. and is now with the Cambridge Electric Light Co. as assistant to the head of the Construction and Repair Department.

EUGENE MESSINGER has left the employ of the Adirondack Power and Light Corp., Schenectady, N. Y., and is now electrical designer in the engineering department of the Otis Elevator Company, New York City.

KARL J. LARSSAN has resigned his position with the Boustead Electric & Mfg. Co., Minneapolis, Minn. and has formed a partnership under the firm name of St. Cloud Electric Machinery Co., St. Cloud, Minn.

HORACE R. J. JONES, formerly with the Pacific Tel. and Tel. Co., Los Angeles, Cal. has accepted a position in the Maintenance Operations Department of the Southern California Telephone Co. of that City.

NEWBOLD C. GOIN and C. V. STEVENS have organized the firm of Stevens-Goin Electric Co., West Building, Jacksonville, Fla., and are now operating as Sales Engineers covering the industrial and central station field.

P. F. STOKES, is now in charge of the manufacture of X-Ray tubes for the Victor X-Ray Corporation, Chicago, Ill. Mr. Stokes was formerly with the Vacuum Tube Dept. of the General Electric Co., Schenectady, N. Y.

PAUL A. CUSHMAN has become Head of the Department of Mechanical Engineering and Mechanic Arts at the University of Arkansas, Fayetteville, Ark. Prof. Cushman was formerly at the Polytechnic Institute, Brooklyn, N. Y.

H. H. JONES is now Vice-president in Charge of Operations of the Northern States Power Co., c/o Minneapolis General Electric Co., Minneapolis, Minn. Mr. Jones was formerly with the San Diego Consolidated Gas & Electric Co., San Diego, Cal.

F. G. SWITZER, recently promoted as Professor of Hydraulics, College of Engineering, Cornell University, has been granted leave of absence in order to undertake work for the Alabama Power Co. in connection with the water power plants of that company. He will be located in the Engineering Department of the Birmingham office.

ERICH HAUSMANN, Thomas Potts professor of physics and professor of electrical communication at the Polytechnic Institute of Brooklyn, was elected president of the New York Electrical Society for the term 1924-25.

Lawrence W. Wallace, Secretary of the American Engineering Council, and Frank B. Gilbreth of Montclair, N. J., have been elected to the Masaryk Academy. This announcement was made by the Ministry of Foreign Affairs of Czechoslovakia in advices to the A. E. C. Mr. Wallace was Vice-Chairman of the Hoover Committee on Elimination of Waste in Industry and Mr. Gilbreth has done notable work in industrial engineering. They will both be participants in the International Management Congress to be held in Prague, July 21-24. Secretary Hoover is Chairman of the committee which is arranging the personnel of the American delegation, and representatives from many lines of industry, research and education are scheduled to address the Congress.

Harry B. Gear, Assistant to Vice-president Ferguson of the Commonwealth Edison Company; Treasurer of the G. & W. Electric Specialty Company and a Fellow of the Institute, has been elected to membership in the Board of Trustees of the University of Chicago. Mr. Gear was graduated from Cornell University in 1895 and has been in the service of the Chicago Edison Company and its successor, the Commonwealth Edison Company, ever since. He is an authority on electrical distribution, and he and Paul F. Williams are the joint authors of *Electric Central-Station Distribution Systems*, a book published in 1910 and since revised and enlarged. He is Chairman of the Safety Codes Committee of the Institute and has done much work for technical and semi-technical societies.

Herman Lemp, engineer in charge of the internal combustion engine engineering department of the General Electric Company at Erie, has resigned his connection with that concern to join the Erie Steam Shovel Company. This follows an association with the General Electric Company for 42 years.

Mr. Lemp joined the staff of Thomas A. Edison early in 1882. In 1887 he was connected with the Thomson-Houston Electric Company in West Lynn, Mass. Later he held the position of chief engineer of the Thomson Electric Welding Company and, in 1895, he joined Professor Thomson in research work. Later he was transferred to the Erie plant of the General Electric Company.

He has been active in the design of electric welding apparatus, self-exciting compound alternating dynamos, and many other types of electrical machinery. In joining the Erie Steam Shovel Company, he will assist in the design of new types of shovels, some of them using the internal combustion engine as a prime mover.

Mr. Lemp became an Associate of the Institute in 1889 and was transferred to the grade of Fellow in 1913.

In recognition of contributions to science, engineering, and large administrative affairs, five officials of the General Electric Company were awarded high honorary degrees by colleges throughout the country during the month of June.

Charles A. Coffin, founder of the Company, was honored by Princeton University with the degree of Doctor of Laws.

Owen D. Young, Chairman of the Board of Directors, and a recent member of the Dawes reparation committee, received the Doctor of Laws degree from Harvard, Tufts and Dartmouth.

Gerard Swope, President of the Company received the degree of Doctor of Science from Union College.

W. L. R. Emmet, in recognition of his research and success in the mercury-vapor turbine and boiler, received a Doctor of Science degree from Trinity College.

Edward R. Berry, who with Professor Thomson and others is largely responsible for the development of clear fused quartz, was honored by Maine University with the degree of Doctor of Science.

Elihu Thomson, one of the founders of the Company and director of the Thomson Laboratory of the General Electric Company at Lynn, Massachusetts, will, on July 14, be given the degree of Doctor of Science at the University of Manchester, England.

Edward Caldwell, Vice-president and Treasurer of the McGraw-Hill Book Company and a member of the Institute since 1891, recently presented a valuable collection of books on early western history to the library of Knox College at Galesburg, Illinois, for the "Finley Collection on the History and Romance of the Northwest." The gift comprised about 1000 volumes, including many rare ones on the early discoveries and explorations in the Mississippi Valley, by Champlain, La Salle, Marquette, Joliet and others. John H. Finley, now Editor of the *New York Times*, for whom the Collection was named, was a graduate of Knox College, and its president for several years, and both Dr. Finley and Mr. Caldwell are now members of its Board of Trustees.

The friends of the late Wm. D. Weaver know that he was a most discriminating collector of books on many subjects, but chiefly on the French Revolution. At the time of his death five years ago his library contained about 3000 titles of books and pamphlets on this important period in French history. This collection was recently purchased from Mrs. Weaver by James H. McGraw and presented to the library of Princeton University. He also provided the money to complete the binding of about 500 volumes and to supply a special book-plate for each volume to indicate that it belonged to the "Weaver Collection on the French Revolution." In presenting the books to Princeton Mr. McGraw wrote: "I make this gift for three reasons: (1) as an expression of my high regard to Mr. Weaver; (2) to make the contents of this valuable library available to the students of a great university; and (3) to show my appreciation of what Princeton University has done for the higher education of the young men of our time, including three of my own sons."

Addresses Wanted

A list of names of members whose mail has been returned by the Postal Authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York, N. Y.

All members are urged to notify the Institute headquarters promptly of any change in mailing or business address, thus relieving the member of needless annoyance and also assuring the prompt delivery of Institute mail, the accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work.

1.—Mamerdo Bauer C., Braden Copper Co., Rancagua, Chile. So. Amer.

2.—J. T. Brown, 522-32nd St., Oakland, Calif.

3.—J. A. Hooper, 195 E. 47th St., Portland, Ore.

4.—Tasashi Iida, Architectural Dept., So. Manchuria Rwy. Co., Dairen, Manchuria.

5.—Herbert A. Kellar, Colorado Power Co., Glenwood Springs, Colo.

6.—Albert H. Lindley, 2616 Kate Ave., Baltimore, Md.

7.—S. F. Nelson, 57 ½ So. Pryor St., Atlanta, Ga.

8.—Thos. W. Rule, 500 Central National Bank Bldg., Topeka, Kans.

9.—R. L. A. Strathy, 369 Clarke Ave., Apt. 5, Westmount, Que., Can.

Past Section and Branch Meetings

SECTION MEETINGS

Akron

American Interconnections and Japanese Power Systems, by Stephen Q. Hayes, Westinghouse Electric & Manufacturing Co. The talk was accompanied by slides and moving pictures. June 5. Attendance 40.

Atlanta

Automatic Generating and Sub-Stations and the Supervisory System of Remote Control, by Chester Lichtenberg, General Electric Co. The lecture was illustrated by lantern slides and moving pictures. May 27. Attendance 75.

Cleveland

The Atmosphere as a Factor in Electrical Engineering, by Professor Harris J. Ryan, President, A. I. E. E. This proved to be a summary of the study of dielectric phenomena and especially the nature of discharges in air. The Annual Dinner of the Section preceded the meeting. The following officers were elected: Chairman, C. P. Cooper; Secretary-Treasurer, R. A. Carle; Chairman, Papers and Meetings Committee, C. L. Dows; Executive Committee, Geo. E. Snider, J. E. Schnable and H. W. Mountcastle. May 22. Attendance 50.

Columbus

Insulation Development and Its Relation to the Electric Art, by C. E. Skinner, Westinghouse Electric & Manufacturing Co. In the afternoon an inspection trip was made through the Army Reserve Depot. The following officers were elected: Chairman, F. R. Price; Secretary, O. A. Robins; Executive Committee, R. J. Feather, A. G. Gibbony, F. C. Nesbit and A. B. Weinfeld. May 23. Attendance 55.

Connecticut

A talk was given by the Honorable John Q. Tilson, member of Congress, third district, Connecticut. Congressman Tilson very interestingly analyzed the political situation existing in our Congress. The meeting was preceded by a dinner. The newly elected officers are: Chairman, William A. Moore; Secretary-Treasurer, Archer E. Knowlton; Executive Committee, A. A. Packard, P. W. Ripple, W. P. Schwabe, B. K. Spencer and C. M. Yale. May 28. Attendance 60.

Denver

Annual Meeting. Held under joint auspices of the Colorado Engineering Council and the Engineering Department of the University of Colorado. The program began in the afternoon with an organ recital. John W. Finch, made a splendid address on engineering opportunities, particularly in the Far East. During the remainder of the afternoon the engineers' laboratories were open for inspection and demonstration by the students. In the evening a dinner was held. Talks upon the relationships between engineers and lawyers were given by John E. Field, Consulting Engineer, and Ward Banister, President of the Denver Chamber of Commerce. The following officers were elected; Chairman W. C. DuVall; Vice-Chairman, V. L. Board; Secretary-Treasurer, R. B. Bonney. May 23. Attendance 270.

Erie

The Mercury Vapor Process, by W. L. R. Emmet, General Electric Co. The lecture was illustrated with slides. May 29. Attendance 200.

Fort Wayne

City Planning, by Robert B. Hanna, President, Indiana City Planning Conference. A banquet preceded the meeting at which Professor Harris J. Ryan, President A. I. E. E., spoke on the activities of the Institute. May 23. Attendance 79.

Indianapolis-Lafayette

Errors in Watthour Meters on Light Low-Power-Factor Loads, and *Three-Phase Four-Wire Metering Schemes*, by Donald T. Canfield, Purdue University. April 25. Attendance 25.

Radio Meeting. Fred R. Finehout, Instructor at Technical High School, Indianapolis, explained the action of vacuum tubes; and showed how the Neutrodyne receiver is a development from the Wheatstone Bridge. The newly elected officers are as follows: Chairman, W. A. Black; Vice-Chairman, D. D. Ewing; Secretary-Treasurer, V. T. Mavity; Executive Committee, C. F. Harding, W. F. Pyle, H. M. Anthony and C. E. Chatfield; Junior Past Chairman, D. C. Pyke. May 16. Attendance 50.

Ithaca

The Atmosphere as a Factor in Electrical Engineering, by Professor Harris J. Ryan, President A. I. E. E. President Ryan described some interesting new developments in the field of high-tension engineering, and related incidents in his work which inspired open-mindedness in research. May 20. Attendance 60.

Kansas City

D-C. and A-C. Automatic Substations Installed in Kansas City, Mo., by D. W. Ellyson, Kansas City Power & Light Co. A dinner preceded the meeting. May 23. Attendance 40.

Los Angeles

Latest Developments in Industrial Motor Application, by H. C. Hill and E. D. Harrington, General Electric Co. Mr. Hill treated the subject from the standpoint of the general application of motors. Mr. Harrington traced the development of elevators from both the mechanical and electrical standpoints. April 28. Attendance 102.

Characteristics of Vacuum Tubes, by Vern O. Knudsen, University of California. Dr. Knudsen discussed from a technical standpoint the development of the vacuum tube. Dr. Knudsen also exhibited an audiometer. May 21. Attendance 92.

Lynn

Annual Business Meeting. The following officers were elected: Chairman, B. W. St. Clair; vice-Chairman, E. D. Dickinson; Secretary-Treasurer, H. S. Twisden; Assistant Secretary, F. S. Jones; Chairman, Membership Committee, D. F. Smalley; Chairman, Entertainment Committee, F. H. Bowman; Chairman, Local Convention Committee, W. H. Pratt; Chairman, Trip Committee, L. R. Wood; Chairman, Publicity Committee, G. W. Roberts; Local Member, Executive Committee, Shirley Mace. May 28. Attendance 80.

Madison

Relays and Protective Devices, by L. N. Chrichton, Westinghouse Electric & Manufacturing Co. Joint meeting with the Meter School, under the auspices of the Wisconsin Utilities Association of the University of Wisconsin. April 15. Attendance 40.

Business Meeting. The following officers were elected for the coming year: Chairman, R. G. Walter; Secretary, Leo J. Peters; Member of Executive Committee, P. J. Weirich. May 7. Attendance 10.

Mexico City

Mexico City's Water Supply, by Mr. Cornejo. April 3. Attendance 17.

Complex Quantities, by Mr. Carrillo. The points which are vital for the proper working of the Section were also discussed. It was decided that the one and only vital point for the Section was the fact that they did not make it sufficiently interesting for the members who spoke only Spanish, as everything which the Institute prints is in English, and although all of the papers presented at the meeting are in Spanish, and Spanish is spoken at the meetings, this is not

enough. The suggestion that the Section print a local JOURNAL in Spanish was then made and considered. May 6. Attendance 14.

The advisability of the Section printing a local JOURNAL was further discussed,—the final decision being to go ahead with plans. Those elected to head it are as follows: Editor in Chief, Mr. Castro; Assistant Editors, Mr. Larralde and Mr. Aubert; Advertising and Business Mgr., Mr. Lopez. The JOURNAL is to be called "Boletin de al Seccion de Mexico, D. F. Del A. I. E. E." May 16. Attendance 23.

Pittsburgh

Alternating-Current Elevator Motors, by C. C. Clymer, General Electric Co. The meeting closed with social entertainment and a buffet lunch. The following officers were elected: Chairman, M. E. Skinner; Secretary-Treasurer, G. S. Humphrey; Executive Committee, J. A. Cadwallader, D. M. Simons, H. E. Dyche, O. Needham, W. S. Schauer, W. C. Goodwin and A. C. Dyer. May 13. Attendance 109.

Milwaukee

Annual Banquet. This was followed by a number of short talks and musical numbers. A. W. Berresford emphasized the relation between the engineer and civic affairs. L. Killan outlined some of the methods used by the Wisconsin Telephone Company in repairing damage to lines caused by sleet storms. C. A. Searles spoke of the relations between the engineer and industry. W. M. White gave some interesting relations between electric power and man power as they affect wages, contrasting the conditions in the United States with some other countries. Mr. Dorner, President of the Milwaukee Engineering Society, made a few remarks about the local engineering organization, urging engineers to be interested in the affairs of their home town. The Wisconsin Telephone Company presented a very interesting sketch demonstrating some of the ways one should not use a telephone. June 5. Attendance 79.

Philadelphia

Some Problems of Gas and Electric Utility Management, by J. T. Hutchings. The speaker called particular attention to the advisability of close cooperation with the local newspapers. He also brought out the difference between hydroelectric power generated at a long distance from the market as compared with steam power generated where needed. Farley Osgood, President-Elect, A. I. E. E., brought out some points which emphasized Mr. Hutching's talk very clearly. May 12. Attendance 150.

Providence

Pulverized Fuel in a Power Plant, by E. H. Couch, Narragansett Electric Lighting Co., and W. C. Slade, United Electric Railways Co. Joint meeting with the A. S. M. E. The following officers were elected for the new year: Chairman, W. B. Lewis; Vice-Chairman, W. P. Field; Secretary-Treasurer, F. N. Tompkins; Executive Committee, D. W. Beaman, Wm. Anderson. May 27. Attendance 75.

St. Louis

The Synchronous Induction Motor, by Val A. Fynn, Consulting Engineer. The speaker's paper dealt with one of the synchronous induction motors which he has personally invented and gave his conception of theory, mode of operation, good qualities and defects. May 14. Attendance 50.

Schenectady

Value of Efficiency in Generating and Transmitting Mechanical Energy, by Charles E. Lucke. The lecture was well illustrated with slides. Joint meeting with A. S. M. E. April 25. Attendance 200.

Radio Broadcasting and Commercial Signalling, by E. F. W. Alexanderson and K. D. Hager. Mr. Alexanderson discussed the technical aspects of radio signalling on a large commercial scale. Mr. Hager gave an interesting talk on the human side of radio and its value to the public. May 2. Attendance 225.

The Influence of Modern Naval Weapons on World Peace, by Rear Admiral Sims. Admiral Sims described methods used in firing guns, directing torpedoes, and sinking depth bombs. May 16. Attendance 750.

Seattle

Annual Meeting. The speaker of the evening was J. L. Stannard, Engineer in charge of the Lake Cushman Power project for the City of Tacoma, who briefly touched upon the main features of the water shed with reference to storage capacity, annual runoff, etc., and by means of slides showed the characteristics of the surrounding country that would become a part of the water shed belonging to the project. Short talks were also given by B. E. Torpen, A. F. Darland and J. V. Gongwehr. The officers elected for the coming year are as follows: Chairman, J. Hellenthal; Secretary-Treasurer, C. E. Mong. May 21. Attendance 90.

Toledo

Dinner Meeting. Short talks were given by a number of members on electric locomotives and transmission systems, electric elevator developments, high-tension cable fault finders, etc. May 16. Attendance 18.

Utah

Early Hydroelectric Development at Ames, Colorado, and Olmstead, Utah, by Paul P. Ashworth.

Telephone Development in Utah, by E. G. Holding.

Early Transmission Practises in Utah, by Wm. Scott. January 25. Attendance 70.

Simplification and Standardization, by C. E. Skinner. March 24. Attendance 60.

The Influence of Engineering on the Development on Modern Civilization, by Carl E. Grunsky, President of the Society of Civil Engineers. There was also a picture exhibited showing the construction of the equipment for the first electrically driven battleship, and one depicting the early days of railroading. Annual Banquet of the Engineering Council of Utah. April 28. Attendance 235.

Vancouver

Business Meeting. The election of officers for the coming year resulted as follows: Chairman, C. N. Beebe; Secretary, A, Vilstrup; Executive Committee, C. N. Beebe, T. H. Crosby. F. W. MacNeil, C. W. Colvin, A. Vilstrup. A dinner preceded the meeting. June 6. Attendance 14.

Washington, D. C.

The Theory of Relativity Visualized, by Professor V. Karapetoff, Cornell University. Joint meeting with Washington Society of Engineers. April 24. Attendance 310.

The Gyro at Work, by Robert B. Lee, Sperry Gyroscope Co. The following officers were elected: Chairman, J. H. Ferry; Vice-Chairman, A. F. E. Horn; Secretary-Treasurer, Frank R. Mueller; Executive Committee, H. B. Stabler and J. F. Meyer. Refreshments were served. May 13. Attendance 103.

BRANCH MEETINGS

University of Alabama

Business Meeting. Officers elected for the new year are as follows: President, L. L. Evans; Vice-President, Daniel Clark; Secretary-Treasurer, C. M. Lang; Publicity Secretary, O. A. Reed. May 6.

University of Arkansas

Development of the Incandescent Lamp, by R. C. Mason. A reel, entitled "Revelations" was also shown. The officers elected for next year are: President, Hugh McCain; Vice-President, Ed Parkes; Secretary, Russell T. Purdy; Treasurer, C. T. Marak. May 22. Attendance 16.

Armour Institute of Technology

Central Station Construction and Opportunities for the Young Electrical Engineer in this Field, by W. F. Sims, Commonwealth Edison Co. May 1. Attendance 50.

University of California

Business Meeting. The officers elected for the new year are: Chairman, F. C. Blacksom; Vice-Chairman, L. J. Herlach; Secretary, M. Nutting; Treasurer, R. O. Brosemer. April 23. Attendance 52.

Carnegie Institute of Technology

Annual Banquet. A talk was given by Samuel H. Church, Board of Trustees of Carnegie Inst. of Technology, on his experiences as an executive. The officers elected for the new year are: Chairman, P. M. Hissom; Vice-Chairman, J. C. Schuchert; Secretary, Donald Beecher; Treasurer, J. W. Hopkins. May 27. Attendance 43.

University of Cincinnati

Annual Banquet. The speaker of the evening was H. C. Blackwell, Vice-President, Union Gas & Electric Co. Short talks were also given by C. B. Hoffman, John Doran, A. C. Burroway and Ray Congleton. Officers elected for the coming year are: President, Ray Congleton; Vice-President, F. E. Sanford; Treasurers, R. W. Fowler, F. S. Hamer; Secretary, W. C. Osterbrock. May 17. Attendance 82.

Colorado Agricultural College

Humanity, by Mr. Taylor. May 12. Attendance 13.

University of Colorado

Alternating Current vs. Direct Current for Trunk-Line Electrification of Railroads. This was a debate by A. H. Barth and L. A. Connelly. Refreshments were served. Officers elected for the coming year are: President, Galen Cartwright; Vice-President, George Best; Secretary, Warren T. Crossman; Treasurer, W. G. Eaton. May 7. Attendance 74.

Growth and Applications of Automatic Substations, by Chester Lichtenberg, General Electric Co. Slides and moving pictures were shown. May 14. Attendance 50.

Iowa State College

The Manufacture of Telephone Cables at Hawthorne Plant, by A. B. Brown. April 2. Attendance 40.

University of Kansas

Business Meeting. Officers elected for the new year are: Chairman, Clyde H. Freese; Vice-Chairman, Roy E. Testerman; Secretary, George R. Vernon; Treasurer, K. E. F. Sharp; Representatives on Engineering Council, Walter B. Farrar, Walter Rising and Randolph W. Gutshall. May 1. Attendance 36.

Lafayette College

The Vacuum Tube and Its Many Applications, by Professor King. May 10. Attendance 19.

Inspection Tour of Dock Street Station of the Pennsylvania Edison Co. May 17. Attendance 19.

Methods of Computing the Rates Charged for Electrical Power, by Professor King. May 24. Attendance 19.

Marquette University

A novel test on a new Westinghouse set was given by Messrs. Moser, Jones and Engeset. Officers elected for the coming year are: Chairman, William J. Hebard; Vice-Chairman, Donald Greensward; Secretary, Clarence Legler; Treasurer, Edward Anfang. May 8. Attendance 36.

Michigan Agricultural College

The Testing of Electric Locomotives, by A. R. Swayer. A film "Electrified Travelogue" on Electrification of Railways was shown.

The Comparison of Vacuum Tubes, by Stewart Seeley. This was followed by a film "The Wizardry of Wireless." May 27. Attendance 40.

University of Michigan

Business Meeting. Officers elected for the coming year are: Chairman, Fred J. Goellner; Vice-Chairman, James B. Johnson; Secretary, Morris H. Lloyd; Treasurer, Henry F. Donner. May 21. Attendance 25.

School of Engineering of Milwaukee

Inspection trip through the Milwaukee Sewage Disposal Plant. June 5. Attendance 62.

University of Minnesota

The Engineer in Business, by Dean Dowrie. A dinner preceded the meeting. Officers elected for the coming year are: Chairman, R. W. Keller; Secretary, H. R. Reed; Treasurer, C. Tunall. May 28. Attendance 52.

University of North Carolina

Business Meeting. Officers elected for the coming year are President, J. B. Smiley; Vice-President, H. C. Klingenschmitt; Secretary, H. L. Col; Treasurer, P. M. Rutherford. May 22. Attendance 24.

Ohio Northern University

Business Meeting. Officers elected for the coming year are: Chairman, Mr. Cotner; Vice-Chairman, Mr. Cresays; Secretary, Mr. Fulks; Treasurer, Mr. Roberts. May 13. Attendance 21.

University of Oklahoma

Picnic Meeting. April 24. Attendance 27.

Oregon State College

Business Meeting. The officers for the coming year were elected. May 8. Attendance 21.

The Peter's Surge Recorder, by A. W. Copley, Westinghouse Engineer. May 15. Attendance 85.

Pennsylvania State College

Business Meeting. Officers elected for the coming year are: President, C. MacGuffie; Vice-President, F. C. Pethick; Treasurer, C. R. Johnson; Secretary, J. H. Schmidt. May 14. Attendance 20.

Rhode Island State College

The Properties of a Magnetic Field, by H. Knolt and John Tower, Jr. May 7. Attendance 20.

The Fundamentals of Radio, by William Anderson. Officers elected for the coming year are: Chairman, C. Stewart North; Secretary, Donald Brown; Executive Committee, Wm. Anderson, C. Stewart North, William Lucker and Joseph Lamb. May 21. Attendance 14.

University of South Dakota

B. B. Bracket spoke briefly on the purpose of the A. I. E. E. Officers elected for the coming year are: President, E. N. Clarke; Secretary, S. M. Lawton; Committee on Programs, Chairman, F. I. Richards, C. S. Barrett, and C. P. Makens. March 27. Attendance 7.

Power Development in 1923, by H. H. Babb. April 4. Attendance 7.

The St. Lawrence River a Waterway to Europe, by Dean F. T. Stockton, College of Arts and Sciences. May 3. Attendance 50.

Stanford University

Manufacture of Transformers (illustrated), by G. H. Corrin, Pittsburgh Transformer Co. May 13. Attendance 19.

Aims and Activities of the American Institute of Electrical Engineers, by H. H. Henline. Initiation Banquet. May 14. Attendance 49.

Moving pictures of water power from United States Bureau of Mines. Officers elected for the coming year are: Chairman, M. L. Wiedmann; Vice-Chairman, Dick P. Fullerton; Secretary, A. C. Wright. June 3. Attendance 24.

University of Tennessee

The Multiplex Telephone System, by Chase Hutchinson. Chas. A. Perkins gave a few points on the theory of the multiplex system and also the wired wireless telephone. Refreshments were served. May 15. Attendance 33.

A. & M. College of Texas

Street Lighting, by Mr. Eargle.

Telephone Systems, by Mr. Bacchus.

Transformers and Their Rating, by Mr. Wall. May 2. Attendance 65.

Business Meeting. The officers elected for the new year are: President, A. A. Ward; Vice-President, L. M. Welch; Secretary, L. H. Cardwell. May 15. Attendance 80.

University of Utah

Inspection Trip to the Utah Power & Light Company's system of hudroelectric plants at and in the vicinity of Grace, Idaho. This trip was very interesting and educational for students of electrical engineering. May 9, 10, 11. Attendance 12.

University of Wisconsin

Motion picture, entitled "White Coal," was shown. June 4. Attendance 34.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers as a cooperative bureau available only to their membership, and maintained by contributions from the societies and their individual members who are directly benefited.

MEN AVAILABLE.—Brief announcements will be published without charge and will not be repeated, except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to **EMPLOYMENT SERVICE, 33 West 39th Street, New York City,** *and should be received prior to the 15th of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription rate of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by nominal contributions made within thirty days after placement, on the basis of $10 for all positions paying a salary of $2000 or less per annum; $10 plus one per cent of all amounts in excess of $2000 per annum; temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above, will, it is hoped, be sufficient, not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case and with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

(For other employment announcements see page 45 of the Advertising section.)

POSITIONS OPEN

SALES REPRESENTATIVES in territory furthest removed from New York. Headquarters, Massachusetts. R-4146

SUPERINTENDENT for electric motor manufacturing plant, familiar with modern manufacturing methods and must know how to reduce costs. Will be under general superintendent of plant. Salary $2500-$3000 depending on experience. R-4064.

MEN AVAILABLE

ELECTRICAL ENGINEER wants permanent connection. B. S. in E. E. 1919. E. E. 1924. four months test, seven months Ass't Hd. Test, fifteen months erecting engineer, G. E. Company, thirteen months power department, the Cleveland Ry. Co., nine months industrial power plant design. Capable of performing duties of electrical engineer, maintenance engineer, or chief draftsman. B-8072

ELECTRICAL ENGINEER, technical graduate, age 28. Two years G. E. test, one year G. E. control engineering, four years anthracite coal company. Development work, motor applications, testing, installation. Available in thirty days.. B-6878

ELECTRICAL MECHANICAL ENGINEER, executive experience, having unusually broad experience in electrical construction and maintenance. Also chief engineer, superintendent general manager of manufacturing plant. Thoroughly versed on production, cost, sales. B-8087

ELECTRICAL ENGINEERING GRADUATE, 35, married. Eight years' practical experience and two years teaching since graduation. Wants public utilities or work in electrical department of jobber of electrical power machinery. Employed now. Must give thirty days' notice. Prefer west or middle west. Perfect health, best references. Associate A. I. E. E. B-8099

ENGINEER-EXECUTIVE desires position as an executive in charge of production, or plant engineering. Fourteen years' rich experience with a leading manufacturer of electrical machinery. Have designed all kinds of labor-saving machinery and developed many new processes. Experience in successfully handling large numbers of employees. University graduate, age 38. B-8153

YOUNG MAN desires position in the operating department of meter department of some power company where he will have a chance for promotion into the engineering department. Semi-technical education with several years' experience in operating department and other electrical fields. B-8150

INSTRUCTOR in electricity and affiliated subjects. B. S. in Electrical Engineering, age 26, American. Associate A. I. E. E. Four years' experience including two years industrial electrical construction and operation, one year electrical drafting and design and one year electrical testing with public utility. Available on sixty days' notice. Will contract for two years' service on $2400 basis. B-8151

ERECTION SUPERINTENDENT. Exceptional experience in power house, substation and industrial construction. Technically educated. Member A. I. E. E. Former army officer. Single, age 40. Available immediately. B-8152

ELECTRICAL ENGINEER, B. S. and E. E. Naval Academy graduate, 33, married. Traveling sales and advisory engineer for large motor manufacturers. Record excellent, desires to locate with architect or large construction company in South America or electrical salesman on road only. Available on two weeks' notice. Salary around $5000 and expenses. B-8174

ENGLISHMAN, 23, single, wishing to specialize in electric traction, desires prospective post in U. S. A. Seven years' power house experience, including articled pupilage. Fully technically trained machine shop practise. High school education. A. I. E. E. Stud. I. E. E., A. M. I. J. E., member E. P. E. A. B-8182

HYDROELECTRIC ENGINEER, interested in connection with waterpower development and investigation. Ten years' experience in construction and operation of power plants and public utilities; four years' consulting practise. American, age 36, Member A. S. M. E., Assoc. Member A. I. E. E. A-2280

ELECTRICAL ENGINEER, graduate M. I. T. 1922. One year teaching, seven months public utilities work. Available immediately. B-8183

ELECTRICAL ENGINEER, technical graduate with five years' experience with large electrical manufacturer; desires position with a power company in engineering of extensions department. Location preferred, east or middle west. Available on short notice. B-8048

GRADUATE ELECTRICAL-MECHANICAL ENGINEER, age 26, single. Six years' experience in the operation of central stations. At present employed but desires a position of greater responsibility and opportunity. Available on short notice. Location preferred, middle west. Minimum salary $3000 a year. B-8185

GRADUATE ELECTRICAL ENGINEER, with accounting education and experience in public utility appraisals, desires position. B-8198

ELECTRICAL ENGINEER, B. S., (M. I. T.) with several years' teaching experience, desires position in the electrical, physics or mathematics department of a college or university. Location immaterial. At present employed as a shop executive in a telephone manufacturing company. B-8199

SALES ENGINEER, technical graduate, now employed, desires change involving more responsibility and increased income. Age 32, excellent health, married, Alexander Hamilton Institute. Over ten years of finest experience in general mechanical lines as well as manufacture, test, design, sales and sales engineering of electric transformers, motors and power-factor corrective apparatus. B-8205

RESEARCH AND TESTING ENGINEER, graduate University of Toulouse, France. Six years university course and laboratory training, two years' technical research experience and ten months A-C. and D-C. apparatus testing, familiar with mathematics and physics, author of many inventions; speaks many languages, single. Desires position with electrical concern recognizing ability. Available immediately. B-7178

B. S. in E. E. June 1916. Two years in engineering department of concern manufacturing electrical equipment. Five years' teaching experience. At present doing graduate work in electrical engineering. Desires teaching position in the electrical engineering department of a college or university. B-7840

ELECTRICAL ENGINEER, technical graduate, member A. I. E. E., open for position. Sixteen years' experience in power plant, substation, distribution lines, transmission lines and street railway operation, maintenance and construction work, including plans and layout. Capable of taking complete charge of work and getting results. B-7942

ELECTRICAL ENGINEER, graduate 1921. Three years' varied experience as field engineer and assistant superintendent on transmission line, distribution line construction, waterworks addition including erection of pump house, installing of equipment and laying three mile pipe. Engineer on appraisal and industrial reports. Desires engineering position of executive nature with responsibility. B-8214

CIVIL-MECHANICAL ENGINEER, graduate, age 37, member A. I. E. E. Broad experience in charge of power and industrial plant and hydraulic work throughout the country, both design and construction. Executive business and management training obtained with well known organizations. B-8163

SALES ENGINEER having served for seven years in an executive capacity as district manager for the sale of electrical apparatus wishes to connect with manufacturer, engineering or sales organization where exceptional salesmanship and technical knowledge is essential. Wide experience on electrical and mechanical apparatus. New York location preferred. B-6151

ELECTRICAL ENGINEER with twenty years' experience in engineering and construction for large power systems. Desires position in eastern states. University graduate in electrical engineering 1899. B-7894

EXECUTIVE of proven ability with a clean record of twenty years in public utilities; from General Electric Company test to general manager public utility. Experience covers the construction of and operation of street railway, power, both hydraulic and steam, gas and general management. References of the best. Now engaged in consulting engineering in New York City. B-2215

ELECTRICAL GRADUATE, age 27, two years' experience, one of them with large electrical manufacturing company. Has wide practical experience in electrical and mechanical trades obtained during summer vacations. Would like to locate with western railroad or manufacturer. B-8229

ELECTRICAL ENGINEER, Purdue graduate, age 34, single. Experience covers operation power plants, long distance transmission lines, high tension substations; sales engineering, executive position operating department large utility in Central West; valuation and rates. Thoroughly experienced in executive capacity. Will go anywhere for reliable firm. Available at once. B-8236

CHIEF ELECTRICIAN, good mechanic, initiative ability, technical education. Seven years' experience with public utility company and engineering firm in industrial and power plants, automatic and remote control of railway and industrial power. Would consider large industrial plant or public service company in middle Atlantic or New England states. Best references, available on fifteen days' notice. B-7005

GRADUATE ELECTRICAL ENGINEER, age 35, married, with varied experience in responsible capacities, desires position as assistant executive, or electrical engineer with progressive steel plant or similar industry. At present employed. B-8194

GRADUATE ELECTRICAL ENGINEER, 35, desires position of responsibility with engineering firm, utility, or as representative of non-technical institution. Broad engineering and business experience as executive, includes determination of designs for power plants, lines, factories, etc., selection of materials and equipment. Construction supervision, investigations of rates, development and financing. B-8237

ELECTRICAL AND MECHANICAL ENGINEER, twenty years' experience; construction, operation and maintenance of steam and hydro-electric power plants. High tension transmission lines and substations, mines, smelters, sugar mills, street railway and long distance telephones. Speak, read, write Spanish, married, no children. Location preferred, tropics. B-8147

ELECTRICAL ENGINEER, experience public utility industry, experimental engineering laboratory, teaching vocational electricity and electrical engineering. Desires to connect with concern requiring services of capable and energetic man. Age 30 years, married. B-8193

TECHNICAL GRADUATE, married, age 28, now supervising design for public utility. Three years design and construction of central substations, seventeen months G. E. test, three years design and standardization automotive electrical equipment. Location vicinity of New York City. Available on reasonable notice. B-8231

B. S. in E. E. 1922, age 27, with experience as office clerk, sign painter, electrician, student Western Electric Companies manufacturing course and substation operation, desires employment in personnel, publicity or instruction work. Southern or south western location preferred. B-8248

ELECTRICAL-MECHANICAL ENGINEER, technical education. Fifteen years' experience in Latin America in construction, operation and maintenance. Thorough knowledge of Spanish. Working knowledge of French and German. Possesses knowledge of selling and purchasing. B-7425

ELECTRICAL ENGINEER, college graduate, age 23, with nine months' experience in testing and developing of transformers, eight months' shop experience, desires position of responsibility as designer or research engineer. Available August 1st, 1924. B-8262

MECHANICAL-ELECTRICAL ENGINEER, 32. Fifteen years' power house and substation construction, transformation and repairs, covering six years service engineer in field, rebuilding and rewinding of larger size turbo generators, rotary commutators, transformers, etc., and one year railway subway experience with 3000-D-C. on Chicago and Milwaukee electrification in Montana. Responsible charge, opportunity for advancement desired. B-8055

GRADUATE ELECTRICAL ENGINEER, age 32. Desires position with a railway, light or power company. Two years Westinghouse Electric testing department, two years' experience on operation, maintenance and installation work of electrical equipment with an industrial firm. Would appreciate an opportunity to become connected with a public utility with opportunities for advancement. B-3018

SUPERINTENDENT of light and power distribution system in charge of a town of 3500 population in Canada; is looking for a larger opportunity. Construction and maintenance, past experience has been practical and thorough. Now serving as manager and superintendent. B-7267

1922 GRADUATE ELECTRICAL ENGINEER, with electrical manufacturing experience, switchboard, and power transmission installations and maintenance, also radio experience. Would be interested in research laboratory, designing or teaching. B-7724

1922 GRADUATE ELECTRICAL ENGINEER, experienced in radio and electrical construction work and testing. Would be interested in research or teaching. B-7760

ELECTRICAL MECHANICAL CONSTRUCTION ENGINEER, married. Twenty years in responsible charge of design, construction, operation and maintenance of equipment in steam, hydraulic and electric power stations. Automatic and manually operated transformer, Edison and railway substations. High tension transmission, net-work and distributing systems, their design and relay protection. Intensive industrial experience in sugar mills, paper mills, coal and gold mining and marine engineering. Five years' machine shop experience. Salary $7000. B-7944

M. I. T. GRADUATE 1922, E. E., Now working at sales promotion and power service installation in large public utility. Would like position in sales, commercial or business work where technical training would be of use. B-6509

MEMBERSHIP — Applications, Elections, Transfers, Etc.

ASSOCIATES ELECTED JUNE 26, 1924

ABBOTT, JOHN MORISSEY, Central Office Repairman, The Pacific Tel. & Tel. Co., 3rd & Seneca Sts., Seattle, Wash.

ADAMS, EDWARD L., Sales Engineer, Kerite Insulated Wire & Cable Co., 709 Peoples Gas Bldg., Chicago, Ill.

ADDISON, ERNEST HENRY, Electrician, Newburyport Gas & Electric Co., 57 Pleasant St., Newburyport; res., Byfield, Mass.

ALLEN, BERT G., President Lakin-Allen Electric Co., 448 W. Larned St., Detroit, Mich.

*ANDERSON, ROBERT V., Jr., Foreman, Neon Light Co., 133 Grand Ave., Brooklyn, N. Y.

ANDERSON, WALKER, Specialist, Industrial Control & Industrial Heating, General Electric Co., Oliver Bldg., Pittsburgh, Pa.

ARNTZEN, EINAR D., 409 Franklin Ave., Vandergrift, Pa.

ASCROFT, CLIFFORD, Manager, Smith, Robinson & Co., Ltd., 925 Douglas St., Victoria, B. C., Can.

ASKLUND, ALF E. 1., Designer Texas Power & Light Co., Interurban Bldg., Dallas Texas.

BADEN, SIEGFRIED CYRIACUS, Editor, Stock Maintenance Dept., Western Electric Co., Inc., 11th & York Sts., Philadelphia; res., Collegeville, Pa.

BAIN, GEORGE FREDERICK, Mill Representative, Copperweld Steel Co., Rankin, Pa.

BAKER, LOWELL EUGENE, Electrical Expert, Westinghouse Elec. & Mfg. Co., 467-10th Ave., New York, res; Brooklyn, N. Y.

BAKER, WALTER R., Maintenance Engineer, New York Telephone Co., 227 E. 30th St., New York; res., Mt. Vernon, N. Y.

BALTEAU, ARTHUR EMILE, Power Man, Michigan Bell Telephone Co., 118 Clifford St., Detroit, Mich.

BARNES, HARRY FORSTER, Division Equipment Engineer, New York Telephone Co., 309 Washington St., Newark; res., Orange, N. J.

BARR, OTTLEY, Engineer, Distribution Engg. Dept., West Penn Power Co., Pittsburgh, Pa.

BARTEK, JOSEPH T., Draftsman, Stone & Webster, Inc., Seattle, Wash.

BEGER, ARTHUR REINHART, Delta Star Electric Co., 2433 Fulton St., Chicago, Ill.

BELL, CHARLES WALDEMAR, Manager, Atlanta Branch, Electric Storage Battery Co., Peachtree & Baker Sts., Atlanta, Ga.

*BENTLEY, CLYDE EDWARD, Electrical Detailing, Pacific Gas & Electric Co., 447 Sutter St., San Francisco; res., Berkeley, Calif.

*BERGSTROM, MARLOW BENJAMIN, Electrical Engineer, J. E. Sumpter Co., 940 Security Bldg., Minneapolis; res., St. Paul, Minn.

BOEKENOOGEN, EARL V., Electrical Designing Engineer, Southern California Edison Co., 1201 W. 2nd St., Los Angeles, Calif.

BOHMFELDT, RUDOLPH R., Jr., Gyro Compass Testing Electrician, Sperry Gyroscope Co., 32 Flatbush Ave. Ext., Brooklyn, N.Y.

BOLLENBACHER, EDWARD HENRY, Electrical Supt. of Construction, McClellan & Junkersfeld, Inc., St. Louis, Mo.

BRADBURY, WILLIAM H., Electrical Engineer, Kingston Coal Co., Kingston, Pa.

BRAISTED, LE ROY, Sales Engineer, C. E. Wise, 2-133 General Motors Bldg., Detroit, Mich.

BREISKY, JOHN V., Electricial Engineer, Supply Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

BREUNING, WALTER P., Chief Electrician, Illinois Glass Co., Bridgeton, N. J.

BROADT, PETER H., Asst. Electrical Engineer, Lehigh Valley Coal Co., Wilkes-Barre, Pa.

BROOKS, ALLERTON FRANK, Cost & Appraisal Engineer, The Southern New England Telephone Co., 157 Church St., New Haven, Conn.

*BROWNELL, FRANK ALLEN, Engineering Assistant, Public Service Production Co., 15 E. Park St., Newark, N. J.

BRUST, ROBERT SHIRLEY, Plant Engineer, The Southern New England Telephone Co., New Haven, Conn.

BRYANT, CLIFFORD CARL, Supt. of Electrical Meter Laboratory, Ottawa St. Station, 215 East Ottawa St., Lansing, Mich.

*BUNYAN, GEORGE ARTHUR, Student, Cornell University, 205 Founders Hall, Ithaca, N. Y.

BURNS, GAVIN AUSTIN, Engineer-in-Charge, Radio Corp. of America, Koko Head, Honolulu, T. H.

BURTON, JAMES ALBERT, Jr., Technical Employee, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.

BUSHNELL, WILLIAM LeROY, Engineer, Service Dept., Westinghouse Elec. & Mfg. Co., 467-10th Ave., New York, N. Y.

BUZBY, ARTHUR DUDLEY, Technical Consultant, Eastern Office, Wellman-Seaver-Morgan Co., 522-5th Ave., New York, N. Y.; res., Montclair, N. J.

*CAMERON, CHARLES F., Instructor of Vocational Electricity, Rock Springs High School, Rock Springs, Wyo.

CARMODY, J. VINCENT, Engineering Dept., New York Telephone Co., 104 Broad St., New York, N. Y.

CARROLL, FRANK DAY, Transmission Engineer, The Pacific Tel. & Tel. Co., 1200-3rd Ave., Seattle, Wash.

*CARROLL, JOSEPH SNYDER, Graduate Student, Stanford University, Stanford University; res., Palo Alto, Calif.

CARTER, WILLIAM LOUIS, Engineer, The Pacific Tel. & Tel. Co., 835 Howard St., San Francisco, Calif.

CHAPIN, BERNARD LORENZO, Junior Electrical Engineer, Stone & Webster, Inc., 147 Milk St., Boston; res., Somerville, Mass.

CHAPMAN, CORWIN CLYDE, Radio Engineer, Federal Telegraph Co., Palo Alto, Cal.

CHATTERJEE, S., Inspector of Telegraphs, Bombay, Baroda & Central India Railway, 62 Fatehgarh, United Provinces, India.

*CLARKE, EARL BADEN, Graduate Student Course, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.

CLARY, HUBERT LERON, Radio Engineer, 3030 Wells St., Milwaukee, Wis.

CLEELAND, WILLIAM J., Transmission Engineer, New York Telephone Co., 309 Washington St., Newark; res., East Orange, N. J.

CLOUD, HOLMAN R., Power Sales Dept., Central Indiana Power Co., 620 Guaranty Bldg., Indianapolis, Ind.

COLCLESSER, RALPH E., Student, Tri-State College of Engineering, Angola, Ind.

CONDE, ANDRES E., Student, School of Engineering of Milwaukee, 415 Marshall St., Milwaukee, Wis.

*COONEY, WILLIAM HENRY, Electrical Engineer, Transformer Engg. Dept., General Electric Co., Pittsfield, Mass.

COOPER, NORMAN L., Electrician, Navy Yard, Washington, D. C.

CORKRAN, AUSTIN G., General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

*CONROY, EDWARD W., Line Foreman, Puget Sound Power & Light Co., Tacoma, Wash.

CORY, SAMUEL I., Engineer, Dept. of Development & Research, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.

COULTAS, FORREST OMAR, Superintendent of Light & Water Plant, Anthony, Kans.

COWAN, JAMES HARRY, Salesman, James Supply Co., Chattanooga; res., Knoxville, Tenn.

CRAFT, FRANCIS M., Building Equipment Engineer, Ohio Bell Telephone Co., 4300 Euclid Ave., Cleveland, Ohio.

CRAMOND, GEORGE WILLIAM, Sales Specialist, Western Electric Co., Inc., 310 Elm St., Cincinnati, Ohio.

CRAWFORD, ROBERT L., Correspondent, Westinghouse Elec. & Mfg. Co., 150 Broadway, New York, N. Y.

CULVERHOUSE, H. A., Salesman, Habirshaw Electric Cable Co., 310 Elm St., Cincinnati, Ohio.

DAVIDSON, CHARLES J., Station Engineer, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.

DAVIS, CHARLES CARROL, Superintendent, Village Electric Dept., Depot Square, Northfield, Vt.

DESAIX, HERBERT W., Manager & Engineer, Watson-Flagg Engineering Co., 214 Straight St., Paterson, N. J.

DIXON, JACK, Meter Man, Puget Sound Power & Light Co., 1306 A St., Tacoma, Wash.

DONAGHEY' CHARLES E., Electric Meter Man, Duquesne Light Co., 3708-5th Ave., Pittsburgh; res., Sewickley, Pa.

*DRAKE, EDWARD F., Engineering Assistant Puget Sound Power & Light Co., 13th & A Sts., Tacoma, Wash.

DRAKE, LEWIS MARVIN, Scientific Research, L. M. Drake Laboratory, Daytona, Fla.

DRISCOLL, WALTER BRIDGES, Engineer, Public Service Co., 915 Pioneer Bldg., St. Paul, Minn.

EBERWINE, ARTHUR FREDERICK, Facilities Engineer, Ohio Bell Telephone Co., 648 Marshall St., Youngstown, Ohio.

*ELIASEN, HENRY, Tester, New York Edison Co., 92 Vandam St., New York, N.Y

ERICKSON, JOHN R., Foreman, Testing Dept., General Electric Co., East Lake Road, Erie, Pa.

EVANS, JAMES H., Engineer, Electrical Division, Dwight P. Robinson & Co., 125 E. 46th St., New York, N. Y.

EVERSON, WALTER A., Salesman, Rumsey Electric Co., Philadelphia; res., Allentown, Pa.

FINGERHART, JOSEPH, Asst. to Chief, Survey Bureau, New York Edison Co., 130 E. 15th St., New York, N. Y.

FINMAN, BENJAMIN, Assistant, Equipment Engineer's Office, Southern New England Telephone Co., New Haven, Conn.

*FISKE, HAROLD COLLINS, Electrical Engineer, J. E. Sumpter Co., 940 Security Bldg., Minneapolis; res., St. Paul, Minn.

FLADER, FRANCIS MAXIMILIAN, Meter Man, Duquesne Light Co., 3708-5th Ave., Pittsburgh, Pa.

FLECKENSTEIN, CONRAD A., Laboratory Assistant Public Service Electric Co., 21st & Clinton Ave., Irvington; res., Newark, N. J.

FLEMING, T. B. General Engineering Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Pittsburgh, Pa.

*FONG, WAH B., Electrical Draftsman, Pacific Gas & Light Co., 445 Sutter St., San Francisco, Calif.

FORMAN, HUGH WORDER, Jr., Plant Engineer, Western Colorado Power Co., Durango, Colo.; res., Pittsburgh, Kans.

FORTUNE, CHARLES LEONARD, Electrical Instructor, William T. Tilden, Jr. High School, 70th & Buist Ave., West Philadelphia; res., Philadelphia, Pa.

FOWLER, FREDERICK, CARLTON, Power Plant Supervisor, New York Telephone Co., 81 Willoughby St., Brooklyn, N. Y.

FRANK, WEYMOUTH FOSTER, Electrical Engineer, Erie Works, General Electric Co., Erie, Pa.

FULLER, DELBERT WILLIAM, Asst. to Signal Engineer, Atchison, Topeka & Santa Fe Railway Co., Topeka, Kans.

GALLAGHER, JOHN JAY, Superintendent, Westinghouse Elec. & Mfg. Co., 160-7th St., Brooklyn, N. Y.

*GANEY, LEO T., Installer, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.; res., Salem, Mass.

GARNER, WILLIAM GLEN, Manager, Rocky Mountain Radio Corp., 2311 Washington Ave., Ogden, Utah.

GASKILL, ELLIOT M., Electrical Inspector, Brooklyn Edison Co., 561 Grand Ave., Brooklyn, N. Y.

GASKINS, RICHARD WILLIAMS, Electrical Engineer, Engineering & Construction Dept., Stone & Webster, Inc., 147 Milk St., Boston, Mass.

GHERSA, UMBERTO, Jefe de Dept., Instalaciones Interiores de la Compania Italo, Argentina de Electricidad, Corrientes 651, Buenos Aires, So. Amer.

GIBSON, CHARLES HENRY, Electrical Foreman, Waterville Shops, Maine Central Railroad, Fairfield, Maine.

GOBLE, JOHN COMBS, Electrician to Construction Foreman, Public Service Production Co., 225 N. Warren St., Trenton, N. J.

GOCHIOCA, EDWARD RICHARD, Test Man, Erie Works, General Electric Co., Erie, Pa.

GOO, RICHARD, Supervising Designer, Thos. E. Murray, Inc., 55 Duane St., New York, N. Y.

GOODMAN, JOSEPH MYER, Sales Engineer, Western Electric Co., Ltd., Johannesburg, So. Africa.

GORTON, ROLLAND ELMER, Technical Laboratory Assistant, Vreeland Wireless Research Laboratory, Stevens Institute of Technology, Hoboken; res., Montclair, N. J.

GRAFF, PAUL TAYLOR, Asst. Research Engineer, Okonite Co., Passaic, N. J.

GRAY, JOHN C., Pacific Tel. & Tel. Co., 520 E. Morrison St., Portland, Ore.

GREENE, FREDERICK, MAYHEW Radio Engineer, Eisemann Magneto Corp., 32-33rd St., Brooklyn, N. Y.

GRIFFITH, CHARLES H., Electrical Engineer, Missouri-Kansas-Texas Railroad, Parsons, Kans.

GURLEY, LEE SIVLEY, Inspector, Underground Subways, Pacific Tel. & Tel. Co., 835 Howard St., San Francisco; res., Redwood City, Calif.

GUSE, RALPH C., Electrical Engineer, California-Oregon Power Co., Medford, Ore.

HAFF, ALEXANDER F., Chief, Inspection Bureau, Distribution & Installation Dept., New York Edison Co., 220-2 E. 38th St., New York, N. Y.

*HALL, RAYMOND A., Supervisor of Cable Testing, The Pacific Tel. & Tel. Co., 835 Howard St., San Francisco, Calif.

HAMM, EDWARD I., Tester, Western Electric Co., Inc., 268 W. 36th St., New York, N. Y.

HARDENBERGH, BLAINE, Electrical Distribution Records, The Ohio Public Service Co., 200 Oberlin Ave., Lorain, Ohio.

*HARDNER, FRANCIS JOS., Telephone Repeater Attendant, American Tel. & Tel. Co., 24 Walker St., New York, N. Y.

HARRIS, CHARLES GANTT, Supervisor Electric Light & Power Relations, The Chesapeake & Potomac Telephone Co., of Va., Richmond, Va.

*HARRIS, SYLVAN, Technical Editor, Radiofax, Lefax Publishing Co., 9th & Sansom Sts., Philadelphia, Pa.

HAUSLER, EDWARD H., Service Engineer, Westinghouse Elec. & Mfg. Co., 1909 Blake St., Denver, Colo.

*HEIM, EDWARD FIELDING, Engineer, Utah Power & Light Co., Salt Lake City, Utah.

HEMMANDER, KARL ADOLF DANIEL, Transformer Draftsman, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.

HENDERSON, DELBERT H., Troubleman, Cleveland Electric Illuminating Co., 75 Public Sq., Cleveland, Ohio.

HERRMANN, AUGUST M., Maintenance Engineer, New York Telephone Co., 360 Bridge St., Brooklyn, N. Y.

*HILL, CHARLES MONTGOMERY, Engineering Clerk, Power Dept., Monongahela West Penn Public Service Co., Fairmont, W. Va.

HILLIARD, GRANT DENTON, Switchboard Operator, Public Service Co., 19 Chauncey St., Trenton, N. J.

*HOCKENBEAMER, EMBREE FREDERICK, Salesman, Westinghouse Elec. & Mfg. Co., 707 First National Bank Bldg., San Francisco; res., Berkeley, Calif.

HOCKER, MERVYN J., Engineering Assistant, Public Service Production Co., 80 Park Place, Newark; res., Bloomfield, N. J.

HODGE, DAVID, Sullivan Machinery Co., Claremont, N. H.

HOLLOWELL, GLENN ALONZO, Student Engineer, General Electric Co., Schenectady, N. Y.

HORSBURGH, JOHN STULL, Engineer, Plant Dept., New York Telephone Co., 336 W. 36th St., New York, N. Y.

HORTER, BAYARD M., District Representative, Cutler-Hammer Mfg. Co., 916 Coal Exchange Bldg., Wilkes-Barre, Pa.

HULSEMAN, GILES DANIEL, Sales Representative, Jos. Dixon Crucible Co., 501 Victoria Bldg., St. Louis, Mo.

JACOBS, OLIVER BURLINGAME, Telephone Engineer, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.

JAMESON, REUBEN MORRIS, Construction Superintendent, Elevator Supplies Co., 1515 Willow Ave., Hoboken; res., Newark, N. J.

*JENNINGS, RALPH S., Maintenance Engineer, Utah Power & Light Co., 133 So. W. Temple, Salt Lake City, Utah.

JOHNSON, ARTHUR C., Asst. Engineer, Postal Telegraph-Cable Co., 253 Broadway, New York, N. Y.; res., Madison, N. J.

JOHNSON, GEORGE ERIK, Designer & Draftsman, The New York Edison Co., 130 E. 15th St., New York, N. Y.

JOHNSON, HOWARD WILLIAM, 166 De Kalb Ave., Brooklyn, N. Y.

JOHNSON, J. HOLMAN, Supervisor of Maintenance & Construction, Fisher Body Ohio Co., E. 140th & Coit Road, Cleveland, Ohio.

JOHNSON, KENNETH H., Machine Switching Tester, Western Electric Co., Inc., 112 W. 20th St., New York, N. Y.

JONES, C. L. Secretary-Manager, Athens County Home Telephone Co., Athens, Ohio.

*JONES, GEORGE WILLIAM, Switchboard Operator, Public Service Electric Co., Trenton, N. J.

*JONES, JOHN WILLIAM, Electrical Designer, Thomas E. Murray, Inc., 55 Duane St., New York; res., Brooklyn, N. Y.

JONES, WALTER L., Asst. Engineer, Public Service Co. of Northern Illinois, 72 W. Adams St., Chicago, Ill.

KAJII, TAKESHI, Telephone Transmission Engineer, Dept. of Communication, Japanese Government, Teishinsho, Tokio, Japan.

KEARNS, EDWARD W., District Manager Habirshaw Electric Cable Co., 500 S. Clinton Ave., Chicago, Ill.

KHASAN, LEON A., Electrical Draftsman, 2109 Harrison Ave., New York, N. Y.

KELLER, WADE THEODORE, Electrical Designer, Stone & Webster, Inc., 147 Milk St., Boston; res., Cliftondale, Mass.

KERR, THOMAS BISHOP, Engineering Assistant, Elec. Engg. Dept., Brooklyn Edison Co., 360 Pearl St., Brooklyn; res., Jamaica, N. Y.

KNIGHT, ROBERT, Asst. Electrical Engineer of Telegraphs, Bombay, Baroda & Central India Railway, Bulsar, India.

*KOCH, WILLIAM A., Jr., Elec. Draftsman, U. G. I. Contracting Co., 1401 Arch St., Philadelphia; res., Lansdale, Pa.

KONDO, HAYAICHI, Electrical Engineer, Shibaura Engineering Works, Shibaku, Tokyo, Japan.

KORINEK, BOHUSLAV, Engineer, Testing Laboratory, Ceskomoravska-Kolben Co., Prague-Vsocany, Czechoslavakia.

KUTCHERA, ALFRED J., President, A. J. Kutchera Co., 822 Second National Bank Bldg., Wilkes-Barre, Pa.

KVAMME, INGOLF FREDRIK, Inspector, System Regulation Division, Duquesne Light Co., Beaver & Seymour Sts., Manchester, Pa.

LANTZ, CALVIN ROY, Chief Electrician, Tacoma Dredging Co., 1113 ½ A St., Tacoma, Wash.

LAWRENCE, OTTO UNKREY, Resident Engineer, Research Corp., Bound Brook, N. J.; for mail, Brooklyn, N. Y.

LEAF, CHARLES L., Sales Representative, Electric Storage Battery Co., 39 John St., Kingston, Pa.

LECHLER, WILLIAM HAVEN, Engineer, Operating Dept., Electric Storage Battery Co., 19th & Allegheny Ave., Philadelphia, Pa.

LEFFERTS, BENJAMIN, Design & Test Engineer, General Instrument Corp., 423 Broome St., N. Y.; res., Brooklyn, N. Y.

LeBOW, ISAAC VEDA, Head Electrical Engineer, Terrell Croft Engineering Co., 6600 Delmar Blvd., St. Louis, Mo.

LEINBACH, JOHN R., Supt., Power & Mechanical Dept., Elk Horn Coal Corp., Fleming, Ky.

*LeROY, CLAUDE ARTHUR, Student, Cornell University, 304 Founders Hall, Ithaca, N. Y.

LEVERIN-JUNGMAN, LOYE JOSEPH, Automatic Control Sub-Stations, Duquesne Light Co., 435-6th Ave., Pittsburgh; res., Mt. Lebanon, Pa.

*LEWIS, AMOS L., The Lewis Electric Co., Skiatook, Okla.

LINDBERG, WILLIAM A., Asst. Engineer, Service Investigation, Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill.

LINDNER, CHARLES P., Equipment Engineer's Office, New York Telephone Co., 309 Washington St., Newark, N. J.

LOCKHART, WILLIAM STANLEY, Engineering Assistant, Public Service Production Co., 80 Park Place, Newark; res., East Orange, N. J.

LOHMAN, RAYMOND C., Salesman, Pennsylvania Electrical Engineering Co., 517 Ash St., Scranton; res., Forty Fort, Pa.

LYONS, SYLVESTER AMBROSE, Student, Tri-State College, Angola, Ind.

MACDONALD, ARTHUR JOHN, Switchboard Engineer, The Pacific Tel. & Tel. Co., 835 Howard St., San Francisco, Calif.

*MAHNKE, EUGENE CHRISTIAN, Student, 206 E. Maumee St., Angola, Ind.

*MANSFIELD, ELWIN C., Testing Dept., General Electric Co., 120 Broadway, New York; for mail, Brooklyn, N. Y.

MARCHAND, ROBERT JOSEPH, Chief Engineer, Transformer Dept., Societie Alsacienne de Constructions Mecaniques, Belfort, France.

MARTINENGO, FREDERICK M., Engineering Assistant, New York & Queens Electric Light & Power Co., Bridge Plaza, Long Island City, N. Y.

MASTEN, LEO BASIL, Power Plant Inspector, Equipment Engg. Dept., New York Telephone Co., 309 Washington St., Newark; res., Bloomfield, N. J.

*MATHIEU, HENRY PHILIP, Field Engineer, M. E. Dept., American Bridge Co., Ambridge, Pa.

MATHUR, ROSHAN LALL, Cables Supervisor, Project Div., Public Works Dept., Raisina, Delhi, India.

McBANE, LOUIS J., Student, Case School of Applied Science, Cleveland, Ohio.

McDAVITT, JOHN GERARD, Machine Switching, The New England Tel. & Tel. Co., Boston; res., Medford, Mass.

McGILL, JOHN HENRY, Acting Asst. Distribution Engineer, Narragansett Electric Lighting Co., Turks Head Bldg., Providence, R. I.

McLAREN, GEORGE SCOBIE, Foreman Radio Dept., Canadian Westinghouse Co., Ltd., Hamilton, Ont., Can.

McMACKIN, LESTER JAMES, Superintendent, Meter Dept., Pennsylvania Edison Co., 2nd & Ferry Sts., Easton, Pa.

*McPHERSON, JOHN DOUGLASS, 3rd, 2nd Operator, Pacific Gas & Electric Co., 1225-15th St., Sacramento; for mail, Fairoaks, Calif.

*McGUIRE, DONALD BALL, Electrical Contractor, New Berlin, N. Y.

MEAD, EDWARD FRANKLIN, Panelboard & Switchboard Engineer, Westinghouse Elec. & Mfg. Co., Baltimore, Md.

MEANY, RAYMOND A., Equipment Engineer, New York Telephone Co., 360 Bridge St., Brooklyn, N. Y.

MELHUISH, LAURENCE EUGENE, Design Engineer, Western Electric Co., Inc., 463 West St., New York, N. Y.; res., Glen Ridge, N. J.

MERGENTHALER, EDWARD FRANCIS, Power Plant, New York Telephone Co., 227 E. 30th St., New York, N. Y.

METZGER, TRUE F., Chief Electrical Engineer, Central Stewart, Stewart, Province of Camaguey, Cuba.

MEYERS, DAVID F., Supt. of Construction, Kentucky & West Virginia Power Co., Sprigg, W. Va.

MILLARD, JESSE B., Supt. of Construction, Hartford Electric Light Co., 266 Pearl St., Hartford, Conn.

MILLER, FREDERICK JACOB, Electrician, Public Service Production Co., 225 N. Warren St., Trenton, N. J.

MILLER, MARVIN L., Traffic Manager, Club Auto Renting Service, 135 W. 33rd St., New York, N. Y.

MILLING, JOHN C., Salesman, General Electric Co., 710 Commerce Bldg., Erie, Pa.
MONTROSE, FRANK A., Chief Engineer & General Supt. of Plant, Indiana Bell Telephone Co., 256 N. Meridian St., Indianapolis, Ind.
MORRISON, JAMES, Electrician, Public Service Production Co., 225 N. Warren St., Trenton, N. J.
MURRAY, MICHAEL J., Test Maintenance Sub-supervisor, Western Electric Co., Inc., Hawthorne Sta., Chicago, Ill.; res., Philadelphia, Pa.
NASH, HUBERT JEPHSON, Electrical Engineer, Bombay, Baroda & Central India Railway Bombay, India.
NEUMANN, ALBERT CARL, Electrician, Public Service Production Co., 225 N. Warren St., Trenton, N. J.
NEWELL, FRANK, Capt., Chief Electrician, West India & Panama Telegraph Co., Ltd., St. Thomas, Virgin Islands.
NEWMAN, REXFORD C., Asst. Electrical Engineer, Susquehanna Collieries Co., Miners Bank Bldg., Wilkes-Barre; res., Kingston, Pa.
NICHOLLS, STERLING WENTZEL, Meter Repair Man, West Penn Power Co., 14 Wood St., Pittsburgh, Pa.
NOLTE, HENRY J., Vacuum Tube Engineer, Research Laboratory, General Electric Co., Schenectady, N. Y.
NORRIS, ERIC DOUGLAS TOBIAS, Chief Transformer Designer, Ferranti Ltd., Hollinwood, Lancashire, Eng.
NOVAK, JOSEPH JOHN, Trunk Plant Engineer, Illinois Bell Telephone Co., 212 W. Washington St., Chicago, Ill.
OMAN, CARL, Electrical Engineer, Supply Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Swissvale, Pa.
ORCUTT, FRANK AMES, Electrical Inspector, New York, New Haven & Hartford Railroad Co., Stamford, Conn.
OTT, WILLIAM N., Electrical Draftsman, Public Service Production Co., 54 ParkPl., Newark, N. J.
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PAGLIUCA, SALVATORE, Apco Manufacturing Co., 1200 Eddy St., Providence, R. I.
PANKHURST, FRANK ARTHUR, Electrical & Mechanical Designing & Estimating, Dominion Bridge Co., Ltd., Lachine, Que., Can.
PAOLINI, MICHAEL, General Tester, Central Service Station, New York & Queens Electric Light & Power Co., Flushing, N. Y.
PARROTT, DAVID FURMAN, Asst. Engineer, Distribution Dept., Northern States Power Co., 15 S. 5th St., Minneapolis, Minn.
PATON, NICOL ANDERSON, Engineer Representative, Westinghouse Electric International, 2 Norfolk St., Strand, London, Eng.
PAUL, PHILIP J., Chief Electrician, Weston Dodson & Co., Inc., Shenandoah, Pa.
PAYNE, BASIL THEODORE, Draftsman, Engg. Dept., Alabama Power Co., Brown-Marx Bldg., Birmingham, Ala.
PAZIN, JOHN CLYDE, Meter Tester, Duquesne Light Co., 3708-5th Ave., Pittsburgh, Pa.
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*PINGREE, HERBERT B., Chief of Meter Dept., Northern Connecticut Light & Power Co., 15 Central St., Thompsonville, Conn.
POOLE, HENRY SAYLE, Designing Engineer, Kerry & Chace, Confederation Life Bldg., Toronto, Ont., Can.
PUXON, EDGAR, Electrical Engineer, Canadian Westinghouse Co., Ltd., Hamilton, Ont., Can.
RAAB, JOSEPH HENRY, District Inspector, Westchester Lighting Co., Mt. Vernon; res., Elmsford, N. Y.
RATH, JOHN C., Engineer, Sanderson & Porter, 72 W. Adams St., Chicago, Ill.
RAYMOND, ERNEST P., Student, Tri-State College, Angola, Ind.
*RAZNIK, EMANUEL ELLIS, Equipment Foreman, American Tel. & Tel. Co., 24 Bank St., Morristown, N. J.
REEVES, GLENN STERRITT, Associate Professor, Dept. of Elec. & Mech. Engg., University of Wyoming, Laramie, Wyo.
RENNICK, W. H., Meter Engineer, Price Electric Co., 12369 Euclid Ave., Cleveland, Ohio.
REUTTER, JULIUS, Stone & Webster, Inc., 147 Milk St., Boston. Mass.
RIGLER, HOWARD MacCALMONT, Asst. Engineer, Portland Electric Power Co., Portland, Ore.
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*ROWLAND, ALBERT, Tester, Toronto Hydro-Electric System, 225 Yonge St., Toronto, Ont., Can.
ROYT, EDWARD S., Asst. to Electrical Engineer, Pfister & Vogel Leather Co., 447 Virginia St., Milwaukee, Wis.
RUBY, MARTIN S., City Manager, City of Lubbock, Lubbock, Texas.
RUNCIMAN, ARTHUR SALKELD, Telephone Engineer, Shawinigan Water & Power Co., Power Bldg., Montreal, Que., Can.
RUSSELL, M. F., Foreman, Substation Maintenance, Kansas City Light & Power Co., 1330 Grand Ave., Kansas City, Mo.
*SABATKE, ERVIN G., Switchboard Installer, Kentucky Utilities Co., Louisville, Ky.; for mail, Beaver Dam, Wis.
SATLER, ROBERT LOWE, Meter Man, West Penn Power Co., West Penn Bldg., Wood & Water St., Pittsburgh; res., Brentwood Boro, Pa.
SCHILLER, HENRY JACOB, Inspector, Brooklyn Edison Co., Inc., 561 Grand Ave., Brooklyn, N. Y.
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SCHROEDER, WILLIAM, Draftsman, Power Dept., The Cleveland Railway Co., Cleveland; res., Lakewood, Ohio.
SEARLES, EDWARD RANDOLPH, Cadet Engineer, Public Service Electric Co., 80 Park Place, Newark; res., West Orange, N. J.
SHADGETT, LAURENCE MOSS, Engineer, Operating Dept., Alabama Power Co., Birmingham, Ala.
SHALLENBERGER, JOHN W., Consulting Electrical Engineer, 945 Main St., Bridgeport, Conn.
SHARP, CLIFFORD S., 5 Geneva St., Jamestown, N. Y.
SHOFFSTALL, HUGH F., Telephone Engineer, Dept. of Development & Research. American Tel. & Tel. Co., 195 Broadway, N. Y.
*SIMMONS, GEORGE HASKEL, Research Engineer, Automatic Electric Co., 947 W. Van Buren St., Chicago, Ill.
SIMMONS, N. KENNETH, Laboratory Assistant, Engg. Dept., Kansas City Power & Light Co., 19th & Campbell, Kansas City, Mo.
SLOCUM, SIDNEY ENSIGN, Power Plant Supervisor, New York Telephone Co., 227 E. 30th St., New York, N. Y.
SMEDLEY, ANDERSON BARDEN, Salesman, Cooper Hewitt Electric Co., 1406 First National Bank, Cincinnati, Ohio.
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*SMITH, CHARLES ROLAND, Engineering Dept., Des Moines Electric Co., 802 Locust St., Des Moines, Iowa.
SMITH, RAY, Chief Electrician, Limestone Products Dept., Pittsburgh Plate Glass Co., Zanesville, Ohio.
SMITH, SAMUEL ARCHIBALD, Jr., Cadet Engineer, Public Service Electric Co., Columbia Ave., Passaic, N. J.; for mail, New York, N. Y.
SONETT, ERWIN, Draftsman, New York Edison Co., 44 E. 23rd St., New York; res., Rockaway Beach, N. Y.
STERN, EMERY, Electrical Superintendent, Schuylkill Railway Co., Girardville, Pa.
STEWART, ROBERT GRAFF, Electrical Foreman, Westinghouse Elec. & Mfg. Co., 469-10th Ave., New York; res., Flushing, N. Y.
STRASSER, JOHN, Electrical Engineer, Power Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
STRONG, JAMES HEUS, Operator, Philadelphia Rapid Transit Co., 2035 Ranstead St., Philadelphia, Pa.; res., Haddonfield, N. J.
SUMMERS, SAMUEL DEWEY, Teacher of Electrical Subjects, Tri-State College, Angola, Ind.
SWAN, RALPH HARPER, Equipment Engineer, New York Telephone Co., 309 Washington St., Newark, N. J.
*SWINDELL, LESLIE EARL, Operating Engineer, Electric Storage Battery Co., 613 Marquette Bldg., Chicago, Ill.; for mail, San Francisco, Calif.
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THOMAS, HARRY E., Electrical Engineer, Interstate Commerce Commission, 1901 D. St., N. W., Washington, D. C.
THURSTON, WILLIAM CONRAD, Engineering Assistant, Bell Telephone Co. of Pa., 261 N. Broad St., Philadelphia; res., Glenside, Pa.
TITLEY, RALPH HENRY, Materials Division Chief, Testing Laboratory, Public Service Electric Co., 21st St. & Clinton Ave., Irvington, N. J.
TODD, PAUL EVERETT, Telephone Engineer, New England Tel. & Tel. Co., 50 Oliver St., Boston, Mass.
TOWNE, HAROLD MERRITT, Electrical Engineer, General Electric Co., Pittsfield, Mass.
TOWNSEND, WILLIAM A., Manager, Public Utilities Division, Vacuum Oil Co., 61 Broadway, New York, N. Y.
TRENCHENY, JOSEPH TIBOR, Electrical Draftsman, McKenzie, Voorhes & Gmelin, 342 Madison Ave., New York, N. Y.
TSURUTA, SENJU, Asst. Chief Engineer, Elec. Engg. Dept., Denki-Kagaku Kogyo Kaisha, Kogyo Club Bldg., Tokyo, Japan.
TULLIO, MASTURZO, Engineer, Societa Napoletana per Imprese Elettriche, Napoli, Italy.
TUTTLE, PLYMMON CARL, Telephone Engineer, American Tel. & Tel. Co., 4300 Euclid Ave., Cleveland, Ohio.
VALLDEJULY, RAMON RODRIGUES, Student, Columbia University, NewYork; res., Brooklyn, N. Y.

*VALLIER, JUSTIN DuBOIS, Switchboard Sales Dept., General Electric Co., Schenectady, N. Y.

VANA, VACLAV V., 105 Beech Ave., Flushing, N. Y.

VAN DAMME, JULIEN JOSEPH CORNELIS, Tester, New York Edison Co., Vandam St., New York; res., Brooklyn, N.Y.

VAN VOLKENBURG, RAY, Electrical Engineer, Consumers Power Co., Jackson, Mich.

VOIGHT, JOHN PETERMANN, Electrical Engineer, Stone & Webster, Inc., 147 Milk St., Boston, Mass.

WALKER, ERNEST WILLIAM, Consulting Engineer, Electric Machinery Co., 28 New Union St., Ancoats, Manchester, Eng.

WALTER, CHARLES LOCKHART, Testing Assistant, Municipal Electricity Dept., Christchurch, New Zealand.

WARREN, ROBERT M., Factory Manager, Dubilier Condenser & Radio Corp., 48 W. 4th St., New York, N. Y.

WATSON, ERNEST WILLIAM, Transmission Engineer, The Pacific Tel. & Tel. Co., 740 S. Olive St., Los Angeles, Calif.

*WEAVER, RICHARD COUNCILL, Asst. Professor of Electrical Engineering, Virginia Military Institute, Lexington, Va.

WEBB, EARL B., Equipment Engineer, Indiana Bell Telephone Co., 256 N. Meridian St., Indianapolis, Ind.

WEEDEN, EDWARD H., Laboratory Assistant, General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

WHITMORE, PETER J., Asst. Supervisor, Switchboard, Publicity, General Electric Co., Schenectady, N. Y.

WHITT, HENRY LLOYD, Chief Electrician, Missouri Pacific Railway Co., Hoisington, Kans.

*WILSON, CARL B., Electrical Engineer, A. C. Engg. Dept., General Electric Co., Schenectady, N. Y.

*WILSON, ROBERT McCRAE, Electrical Engineer, General Electric Co., Bloomfield; res., Montclair, N. J.

WOLFE, EDGAR LEROY, Tester, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.

WOODSON, RICHARD KIDDER, Underground Engineer, Kansas Power & Light Co., 1330 Grand Ave., Kansas City; res., Liberty, Mo.

WULFF, ANDREW C., First Grade Inspector, Brooklyn Edison Co., 561 Grand Ave., Brooklyn, N. Y.

XENAKIS, JAMES, 211 East 33rd St., New York, N. Y.

YERKES, FRANK C., Superintendent, Electric Meter Service Dept., Public Service Co. of Colorado, 2145 Blake St., Denver, Colo.

YOSUGI, KYOJIRO, Electrical Engineer, Yokohama Electric Wire Works, The Furukawa Electric Co., Ltd., Nishi-Hiranum, Yokohama, Japan.

Total 296

*Formerly Enrolled Students

ASSOCIATES REELECTED JUNE 26, 1924

DARLING, GEORGE F., Manufacturer's Representative, Electrical Lines, 705 Plymouth Bldg., Minneapolis, Minn.

EICHEL, EUGEN, Consulting Engineer, 15 Heilbronner St., Berlin W. 30, Germany.

SUDLOW, HARRY, Manager, The Carolina Light & Power Co.; Superintendent, Water Works, City of Aiken, Aiken, S. C.

VANDERVOORT, GERALD, Supt. of Operation, New Brunswick Electric Power Commission, Musquash, N. B., Can.

ASSOCIATE REINSTATED JUNE 26, 1924

FINNEY, THOMAS JOHN, JR., Field Engineer, Public Service Production Co., Kearny, N. J.; res., Stamford, Conn.

MEMBERS ELECTED JUNE 26, 1924

CROWDER, SAMUEL R., Office Layout Engineer, Western Union Telegraph Co., 195 Broadwy, New York, N. Y.

EGIAZAROFF, JOHN BASIL, Professor, Electrotechnical Institute, Pesotchnaya 5, Petrograd, Russia.

EHRENFELD, RALPH, Section Engineer, Small Motor Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

HAMILTON, HAROLD S., Telephone Engineer, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.

LELAND, GEORGE HAROLD, President & Designing Electrical Engineer, The Leland Electric Co., Dayton, Ohio.

LEONARD, STUART GREENE, Electrical Engineer, The Cleveland Railway Co., Hanna Bldg. Annex, Cleveland, Ohio.

McLEOD, NEIL GLOSTER, Consulting Engineer, Partner, Gauvain & McLeod, 60 Shortland St., Auckland; res., Hamilton, N. Z.

POTTS, WALTER F., Equipment Engineer, Machinery Dept., Rumsey Electric Co., 1007 Arch St., Philadelphia, Pa.

ROBERTSON, ELGIN BARNETT, Electrical Engineer, Railway & Industrial Engineering Co., Greensburg, Pa.

SLACK, EDGAR P., Asst. Engineer, Underwriters' Laboratories, 109 Leonard St., New York, N. Y.; res., East Orange, N. J.

WEILAND, CHRISTIAN FREDERIK, Engineer, Consumers Power Co., Jackson, Mich.

MEMBER REELECTED JUNE 26, 1924

DOYING, WILLIAM ALBERT EDWARD, Inspecting Engineer, The Panama Canal, Washington, D. C.

FELLOW ELECTED JUNE 26, 1924

SMOUROFF, ALEXANDER, Professor, Electrotechnical Institute, Pessochnaja 5, log 8, Petrograd, Russia.

TRANSFERRED TO GRADE OF FELLOW JUNE 26, 1924

BOYRER, WILLIAM CHARLES, Electrical Engineer, Public Service Commission, State of New York, New York, N. Y.

SPENCER, CLARENCE G., Engineer, McClellan & Junkersfeld, Inc., New York, N. Y.

WITHINGTON, SIDNEY, Electrical Engineer, New York, New Haven & Hartford Railroad, New Haven, Conn.

TRANSFERRED TO GRADE OF MEMBER JUNE 26, 1924

CALDERWOOD, EVERETT M., Engineer, Pacific Tel. & Tel. Co., San Francisco, Calif.

CONE, D. I., Protection Engineer, Pacific Tel. & Tel. Co., San Francisco, Calif.

DELEHANTY, WALTER J., Representative General Electric Co., Sacramento, Calif.

DEWEY, FRED S., Assistant General Manager, Kansas City Power & Light Co., Kansas City, Mo.

GIBBS, CLARENCE D., Dwight P. Robinson & Co., New York, N. Y.

IDAIL, MURRAY J., Electrical Engineer with Francis R. Weller, Washington, D. C.

MACKLER, LOUIS, Leading Electrical Draftsman, New York Edison Co., New York, N. Y.

MAHAN, JAMES S., Electrical & Fire Prevention Inspector, Western Actuarial Bureau, Chicago, Ill.

McELROY, GEORGE, Manager, Bridgeport Office, Westinghouse Electric & Mfg. Co., Bridgeport, Conn.

MONTSINGER, VINCENT M., Consulting & Research Engineer, General Electric Co., Pittsfield, Mass.

RUHLING, T. C., Superintendent, Underground Construction, Kansas City Power & Light Co., Kansas City, Mo.

SMITH, ELMER A., Consulting Electrical Engineer, Warren & Wetmore, New York, N. Y.

STRYKER, CLINTON E., Assistant Professor of Electrical Engineering, Armour Institute of Technology, Chicago, Ill.

TAYLOR, CHARLES H., Chief Communications Engineer, Radio Corporation of America, New York, N. Y.

THOMSON, GEORGE L. A., Electrical Division Chief, Testing Laboratory, Public Service Electric Co., Irvington, N. J.

THORNTON, WILLIAM NELSON, Lieut. (junior grade) U. S. Navy, Bureau of Navigation, Navy Department, Washington, D.C.

WOOLSTON, LOUIS F. B., Engineer, General Electric Co., St. Louis, Mo.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting held June 16, 1924, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary.

To Grade of Member

JONES, BENSON M., Switchboard & Control Engineer, Duquesne Light Co., Pittsburgh, Pa.

SHULER, WILLIAM, Electrical Engineer, Dayton Power & Light Co., Dayton, Ohio

THORMAHLEN, ARTHUR, Plant Engineer, Durant Motors of Canada, Leaside, Ont.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a higher grade than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before July 31, 1924.

Agostino, T. G., 152 E. 112th St., New York, N. Y.

Ahmed, S. H., Commonwealth Edison Co., Chicago, Ill.

Allen, E. B., Allen Engineering Co., Hamilton, Ont., Can.

Bosshardt, W. C., Fosston Mfg. Co., St. Paul, Minn.

Boumeester, H. G., 230 West 99th St., New York, N. Y.

Bradford, A. O., Mexican Light & Power Co., Necaxa, Pueblo, Mex.

Briggs, H. P., Atlantic City Electric Co., Atlantic City, N. J.

Brown, E. K., 113 E. 26th St., New York, N. Y.

Calvert, F., General Electric Co., Schenectady, N. Y.

Campbell, D. S., Washington Water Power Co., Spokane, Wash.

Carhart, F. M., (Member), Jackson & Moreland, Boston, Mass.

Carter, S. E. C., The New York Edison Co., New York, N. Y.

Carvill, A. L., Public Service Electric Co., Newark, N. J.

Clapp, J. B., Public Service Electric Co., Newark, N. J.

Clark, H., Drexel Institute, Philadelphia, Pa.

Clayton, H. M., Arkansas Central Power Co., Little Rock, Ark.

Coon, I. F., Commonwealth Edison Co., Chicago, Ill.

Curran, R. W., (Member), Portsmouth Public Service Co., Portsmouth, Ohio

Davis, E. K., (Fellow), Elec. & Mech. Engr., Peale Interests, St. Benedict, Pa.

Denzler, M. F., (Member), Scintilla Magneto Co., New York, N. Y.
Farish, E. T., 102 Jamaica Ave., Flushing, N. Y.
Fisken, James B., The Washington Water Power Co., Spokane, Wash.
Franklin, R. F., General Electric 3o., Schenectady, N. Y.
Frey, J. N., Westinghouse Elec. & Mfg. Co., Newark, N. J.
Gausz, J., New York Edison Co., New York, N. Y.
Goodyer, A. A., The Southern New England Tel. Co., New Haven, Conn.
Gordon, W. J., Philadelphia Electric Co., Philadelphia, Pa.
Greene, J. J., United Electric Light & Power Co., New York, N. Y.
Hance, P. D., Jr., Western Electric Co., Inc., Hawthorne Wks., Chicago, Ill.
Hansa, F., (Member), Guaranty Trust Co., Abell, Smalley & Myer, New York, N. Y.
Hearn, R. J., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Herbert, E. S., Frankel Connector Co., New York, N. Y.
Hoilman, C. W., General Electric Co., Lynn, Mass.
Hunter, S. C., Puget Sound Power & Light Co., Seattle, Wash.
Johnson, R. C., Kansas City Power & Light Co., Kansas City, Mo.
Jones, F. R., Western Union Telegraph Co., Boston, Mass.
Kestner, P. W., Westinghouse Lamp Co., Bloomfield, N. J.
Kimmel, J. J., Consolidated Gas, Elec. Light & Power Co., Baltimore, Md.
Kinney, H. S., University of Nebraska, Lincoln, Nebr.
Knecht, F. A., Consolidated Gas & Electric Co., Baltimore, Md.
Kramer, T. M., Sewickley Electric Mfg. Co., Sewickley, Pa.
Lange, H. L., Board of Fire Underwriters of the Pacific, Butte, Mont.
Lemann, W., 408 W. 49th St., New York, N. Y.
Lesser, W. H., (Member), Madeira Hill & Co., Frackville, Pa.
Lynch, W. C., Aluminum Co. of America, San Francisco, Calif.
Macrini, F., 1024 Cauldwell Ave., New York, N. Y.
Marconi, C. G., Brooklyn Edison Co., Brooklyn, N. Y.
Markus, L., Electrical Engineer, 1102 53rd St., Brooklyn, N. Y.
Martens, C., Western Electric Co., Inc., New York, N. Y.
McIlvane, E. W., West Penn Power Co., Pittsburgh, Pa.
Milner, T. C., Georgia Railway Power Co., Tallulah Falls, Ga.
Moorehouse, T., Lowell Gas Light Co., Lowell, Mass.
Murphy, W. E., East End Electric Co., Wilkes-Barre, Pa.
Noest, J. G., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Nolan, T. J., Toledo Edison Co., Toledo, Ohio
Ott, E., English Electric Co. of Canada, Ltd., St. Catharines, Ont., Can.
Phelan, T. E., Radio Corp. of America, New York, N. Y.
Pisano, G. H., with Edward F. Caldwell & Co., Inc., New York, N. Y.
Rehmann, P. C., Franklin Porcelain Co., Norristown, Pa.
Roeller, H. C., Stanley G. Flagg & Co., Stowe, Pa.
Rutherford, E. J., American Tel & Tel. Co., New York, N. Y.
Rymes, C. E., Hydro-Electric Power Commission, Hydro, via Port Arthur, Ontario, Can.
Rypinski, M., Brooklyn Edison Co., Brooklyn, N. Y.
Scola, B., 278 1st Street, Brooklyn, N. Y.
Sealamandre, F., Westinghouse Elec. & Mfg. Co., Newark, N. J.
Sharma, G. C., Purdue University, West Lafayette, Ind.
Smith, A. B., American Brass Co., New York, N. Y.
Snyder, W. B., General Electric Co., Schenectady, N. Y.
Soule, J. F., Chicago Electric Co., Chicago, Ill.
Sparks, S. W., Jr., Duquesne Light Co., Pittsburgh, Pa.
Stimpson, C. A., Chicago Pneumatic Tool Co., Pittsburgh, Pa.
Tombler, G. E., Kueblers Foundries, Inc., Easton, Pa.
Torres, T. R., Mexican Light & Power Co., Indianvilla, Mexico City, Mex.
Walker, E. R., Brooklyn Edison Co., Brooklyn, N. Y.
Ward, R. B., Elec. Bureau, Dept. of Public Safety, Newark, N. J.
Webster, F. P., Brooklyn Edison Co., Brooklyn, N. Y.
Wellwood, R. M., Britannia Mining & Smelting Co., Britannia Beach, B. C., Can.
Wendt, M. F., Elevator Supplies Co., Hoboken, N. J.
Wild, R. M., Stone & Webster, Inc., Boston, Mass.
Wood, W. A., Jr., Cleveland Electric Illuminating Co., Cleveland, Ohio
Woringer, M., 231 W. 22nd St., New York, N. Y.
Total 81

Foreign

Elliott, S. R., Burma Corp. Ltd., Burma, India
Gallagher, C., Metropolitan-Vickers Elec. Co., Ltd., Trafford Park, Manchester, Eng.
Howarth, O., Lancashire Electric Power Co., Manchester, Eng.
Matsumoto, H., "Keihan" Electric Railway Co., Teumabashi, Osaka, Japan
Mestraud, A., (Member), Societe Generale d'Entreprises, St. Honore, Paris
Tata, N. N. D., The Andhra Valley Power Supply Co., Ltd., Camp Dharavi, Bombay, India
Total 6

STUDENTS ENROLLED JUNE 26, 1924

18986 Sparks, Leroy V., Marquette University
18987 Schnerer, Henry M., Ohio State University
18988 Johnson, Reverdy, Mass. Institute of Tech.
18989 Durstine, John E., Ohio State University
18990 Gollay, Nathan, Lewis Institute
18991 Schneider, Robert E., Univ. of Illinois
18992 Elker, Herbert R., Yale University
18993 Ayer, Raymond B., Northeastern Univ.
18994 Ritner, Fred C., Oregon State Agricultural College
18995 Hessler, Victor P., Oregon State Agricultural College
18996 Davis, C. W., Purdue University
18997 Bathgate, Kenneth K., Univ. of California
18998 Bejarano, Gabriel G., Univ. of California
18999 Bejarano, Julio G., Univ. of California
19000 Black, George J. F., Univ. of California
19001 Black, Richard H., Univ. of California
19002 Brolly, Archibald H., Univ. of California
19003 Brosemer, Robert O., Univ. of California
19004 Croco, Charles P., University of California
19005 Daniels, John S., University of California
19006 Dempster, John R., Univ. of California
19007 Driskell, Fay L., University of California
19008 Dunkel, Leonard N., Univ. of California
19009 Edwarde, Leo K., University of California
19010 Fischer, Hymen, University of California
19011 Geering, Grafton R., Univ. of California
19012 Grignon, Lorin D., University of California
19013 Jones, Frank C., University of California
19014 Mueller, William E., Univ. of California
19015 Powell, Walter N., University of California
19016 Sander, Charles P., University of California
19017 Scherb, Fran M., University of California
19018 Selby, Eugene O., University of California
19019 Stuart, Roy F., University of California
19020 Waldorf, Wallace A., Univ. of California
19021 Weck, Gustave B., Univ. of California
19022 Baptie, Charles C., Stanford University
19023 Ferris, Paul B., University of Illinois
19024 Boolos, Stephen G., Columbia University
19025 Anderson, Elmer W. N., Brown University
19026 Goodrich, Charles S., Tri-State College
19027 Hopkins, Thomas J., Jr., Howard University
19028 Proescholdt, Walter H., Iowa State College
19029 Loh, M. S., University of Illinois
19030 Ramadanoff, D., University of Illinois
19031 Jilly, Ralph F., University of Illinois
19032 Rittenmayer, Clyde, University of Illinois
19033 Tames, John A., University of Alberta
19034 Berry, Russell J., University of Michigan
19035 Kron, Gabriel, University of Michigan
19036 West, George R., University of Toronto
19037 Gerstein, Emanuel, Harvard University
19038 Hickey, Frederic M., Harvard University
19039 Gardner, J. Carl, University of Colorado
19040 Hawkes, Fayette T., Tri-State College
19041 Roberts, Gerald G., Ohio Northern Univ.
19042 Vicario, Carlo, Mass. Institute of Tech.
19043 Pennybacker, Miles W., Mass. Institute of Technology
19044 Manke, Arthur, University of Wisconsin
19045 McMillan, James, University of Alberta
19046 Miller, Henry V., University of Santa Clara
19047 Tudor, Richard L., New Mexico College of A. & M. Arts
19048 Williams, Clayton W., Texas A. & M. College
19049 Lamb, Joseph M., Rhode Island State College
19050 Russell, Lewis H., University of Idaho
19051 Cromwell, Paul C., Carnegie Institute of Technology
19052 King, Timothy P., University of Wisconsin
19053 Jackson, Jerry T., University of Illinois
19054 Moreira, Eugene A., Columbia University
19055 Talbott, Edward P., Purdue University
19056 Allen, Vern S., Purdue University
19057 Henshaw, Marshall D., Virginia Polytechnic Institute
19058 Pixton, William G., Emory University
19059 Clarke, Luke, Rhode Island State College
19060 Birch, Albert F., Harvard University
19061 Barber, Hiram W., Jr., Rhode Island State College
19062 Dueno, Fred H., University of Wisconsin
19063 Whitney, Charles S., Jr., Cornell Univ.
19064 Burnett, Newton O., Cornell University
19065 Roper, J. Walter, Mass. Institute of Tech.
19066 LeBel, Clarence J., Mass. Institute of Technology
19067 Caswell, Ralph W., University of Illinois
19068 Forsyth, Roland B., Mass. Institute of Technology
19069 Weil, Charles F., University of Washington
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Worcester	L. E. Pierce	Stuart M. Anson, 1005 Park Bldg., Worcester, Mass.

Total 47

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Alabama, Univ. of, University, Ala.	C. S. Carlton	W. F. Graham
Arizona, Univ. of, Tucson, Ariz.	Roy Osborne	Edward Moyle
Arkansas, Univ. of, Fayetteville, Ark.	J. A. Cunningham	C. E. Bowman
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Brooklyn Poly. Inst., Brooklyn, N. Y.	H. B. Hanstein	J. E. Loerch
Bucknell Univ., Lewisburg, Pa.	E. S. Hopler	A. L. Huffman
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California, Univ. of, Berkeley, Calif.	S. W. Scarfe	F. E. Hurt
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Cincinnati, Univ. of, Cincinnati, O.	J. F. Morrissey	C. B. Hoffmann
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Clemson Agri. College, Clemson College, S. C.	R. W. Pugh	O. A. Roberts
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Colorado, Univ. of, Boulder, Colo.	M. B. Inman	C. V. Roberts
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Denver, Univ. of, Denver, Colo.	C. G. Diller	Ray Hoover
Drexel Institute, Philadelphia, Pa.	H. Shelley	D. L. Michelson
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Georgia School of Tech., Atlanta, Ga.	R. A. Goodburn	J. A. Minor
Iowa State College, Ames, Iowa	A. Paone	R. E. Paxton
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Kansas, Univ. of, Lawrence, Kans.	H. A. Hudson	R. M. Ryan
Kentucky, Univ. of, Lexington, Ky.	K. R. Smith	J. D. Taggart
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Marquette Univ., Milwaukee, Wis.	E. O. Triggs	N. W. Hoffman
Massachusetts Inst. of Tech., Cambridge, Mass.	G. P. Davis	F. J. Hecht, Jr.
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Rutgers College, New Brunswick, N. J.	E. G. Riley	E. J. Butler
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Yale Univ., New Haven, Conn.	W. C. Downing, Jr.	O. B. Skinner

Total 76

DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies.

Lighting for Hotels and Restaurants.—Bulletin L. D. 151, 32 pp. Edison Lamp Works of General Electric Company, Harrison, N. J.

Circuit Breakers.—Bulletin 560, 8 pp. Describes Type E Roller-Smith "Safety" air circuit breakers (enclosed). Roller-Smith Company, 12 Park Place, New York.

Diesel Engines.—Bulletin, 4 pp. Describes Fulton Diesel engines as used in various industries. Fulton Iron Works Company, St. Louis, Mo.

Synchronous Motors.—Bulletin 833, 8 pp. Describes E-M Junior synchronous motors for direct connection to small compressors. Electric Machinery Manufacturing Company, Minneapolis, Minn.

Conduits and Fittings.—Catalog J, 80 pp. Describes the Austin line of electric wires, cables, conduits and fittings. M. B. Austin & Company, 108 So. Desplaines Street, Chicago, Ill.

Lighting Data.—Bulletin L. D. 0, 14 pp., an index of information contained in lighting data bulletins previously published. Edison Lamp Works of General Electric Company, Harrison, N. J.

Transformers.—Bulletin 2030, 4 pp. Describes copper alloy steel tanks used in Pittsburgh transformer construction. Pittsburgh Transformer Company, Columbus & Preble Avenues, Pittsburgh, Pa.

Circuit-Breaker.—Handbook, 96 pp. Describes the "U-Re-Lite," steel enclosed air circuit breaker. A handsomely bound volume, comprehensively illustrated, shows typical installations. The Cutter Company, 19th & Hamilton Streets, Philadelphia, Pa.

A. C. Portable Instruments.—Bulletin 160, 12 pp. Describes type G S A ammeters, voltmeters, volt-ammeters, single and polyphase wattmeters, frequency meters, power factor meters, transformers, multipliers, "Y" boxes. Roller-Smith Company, 12 Park Place, New York.

Transformers.—Bulletin 2031, 4 pp. Describes a new expansion tank type transformer in which the main tank is filled with oil and an auxiliary expansion tank provided to prevent breathing in the main tank. Pittsburgh Transformer Company, Columbus & Preble Avenues, Pittsburgh, Pa.

Circuit Breaking Plugs and Receptacles.—Catalog, 12 pp. Describes "Arktite" plugs and receptacles which embody an entirely new principle in plug and receptacle construction and which meets the demand for circuit-breaking plugs and receptacles in capacities heretofore considered impractical. Crouse-Hinds Company, Syracuse, N. Y.

Oil Switches and Circuit Breakers.—Bulletin 454, 2 pp. Describes Type D-13B Condit oil switches and circuit breakers. This apparatus was designed for use in medium sized distributing systems where single-unit construction is desirable. *Bulletin 455, 4 pp.*, describes type F-11 Condit oil switches and breakers. These are of the truck type construction, mechanically interlocked, and require a relatively small amount of floor space. The bulletin also includes special application of the type F-11, that is, automatic disconnects and accessories, providing a very compact unit and affording extreme flexibility. *Bulletin 456, 4 pp.*, describes electrically operated mechanism for automatic closing and reclosing of oil switches and circuit breakers (indoor or outdoor) by direct or alternating current. Condit Electrical Manufacturing Company, South Boston, Mass.

Pyrometers.—Book, 72 pp., "Instructions for Installation and Care of Thermo-Electric Pyrometers."—Describes various methods of wiring indicators and recorders, methods of eliminating cold junction errors, methods of installing couples, and of checking thermo-couples, wiring, or the accuracy of the instruments. These subjects are gone into from practical and theoretical angles, as well as such other subjects as open and conduit wiring, mounting the instruments, locating defects in the thermo-electric circuit by various means, and many other practical hints. The book also contains temperature millivolt equivalents for thermo-couples and conversion of Fahrenheit and Centigrade scales. The Brown Instrument Company, Philadelphia, Pa.

NOTES OF THE INDUSTRY

Economy Fuse & Manufacturing Company have moved their Chicago district sales office from 536 Transportation Building to larger quarters at 513 West Jackson Boulevard.

Morgan P. Ellis has been appointed general sales manager. He has been assistant general sales manager for the past eight years.

A Laboratory Socket and Switch Testing Machine has been developed by Harvey Hubbell, Inc., Bridgeport, Conn., by which lamp sockets, switches or other devices operated by means of a spring actuated mechanism for making and breaking circuits can be tested for overload, endurance and heat before being accepted for general use. It is understood that this is the first machine to successfully test toggle switches.

Black & Decker Manufacturing Company, Towson, Md.—The Board of Directors held their regular quarterly meeting on June 19, and declared the usual 2% dividend on preferred stock, as well as a 2% dividend on common stock. It is interesting to note that in addition to maintaining the payment of the preferred dividends that the company has also paid at the rate of 8% per year on its common stock.

Transformer Oil Tester.—A new device has been developed by the General Electric Company for testing oil in transformer drums without the necessity of drawing samples. The device can be used in connection with any 25 or 30 kilovolt testing transformer, with the exception of those having the middle point of their high tension grounded. By means of this new tester, the oil testing gap is inserted into the drum through the bung and an immediate indication of the condition of the oil is given.

The General Electric Company has awarded a contract to the Turner Construction Company of New York, for a six-story, reinforced concrete building, 600 feet long by 80 feet wide, to be erected at West Philadelphia. This building, in connection with two one-story structures now nearing completion, will be the initial development of a plant to be devoted entirely to the manufacture of switchboard devices. The ultimate development of the plant contemplates erection of two additional similar multi-story buildings, the three buildings to be connected. The total area of the new plant will be about 1,750,000 square feet floor space. The buildings now under construction will be ready for occupancy about July 1, 1924 and the building recently contracted for will be ready for occupancy early in 1925.

New Steel Pole Producer.—Announcement is made by the Truscon Steel Company, Youngstown, Ohio, that the new steel pole department is now ready for a quantity production schedule and is prepared to manufacture all sizes of steel poles up to 50 ft. in length. A feature of the Truscon steel pole is its simplicity of construction, being pressed from 5 inch to 12 inch steel channels or I beams. It is so designed that no special equipment is needed by the linemen in ascending or descending, thus eliminating pole steps and the necessity for use of spurred climbers. Subjected to all practical tests under varying conditions over a period of two years, this pole, like all other Truscon products, was perfected by engineers before production was begun and the pole was placed on the market. It is claimed by the manufacturers that when the pole is anchored in concrete and painted about once in five years it will last indefinitely. Due to simplification of manufacture and quantity production the cost of the steel pole is about the same as of wood poles. A complete line of fittings has been designed for these poles to fit any size standard cross-arm, either wood or steel.